3D VIRTUAL SIMULATION OF CLOTHES FITTING AND FABRIC DRAPING

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ABSTRACT: *The primary goals of CAD/CAM systems are to promote designer productivity and enhance design quality. Simultaneously, the general level of competition among the companies in the industry can also be increased. Recently, many CAD systems have offered the construction of three-dimensional models, which may be seen on various avatar models and from multiple angles. One of the largest obstacles to fashion design and production is the evaluation of garment fit, be preserved, exhibited, and reconstructed in new ways. The aim of this study is to demonstrate how using the computer program Clo3D, it is possible to compare one female dress model on different avatars, and 3D Virtual material draping with various fabric weights may be selected without the need for real sample stitching. Engineers and designers can use many tools and features provided by Clo3D to produce and express 3D clothes in a realistic virtual way.*

Keywords: *Clo3D, virtual, fit, avatar, drape.*

3D VIRTUELNA SIMULACIJA PRISTAJANJA ODJEĆE I DRAPIRANJA TKANINE

APSTRAKT: *Primarni ciljevi CAD/CAM sistema su promovisanje produktivnosti dizajnera i poboljšanje kvaliteta dizajna. Istovremeno se može povećati i opšti nivo konkurencije među kompanijama u industriji. Nedavno su mnogi CAD sistemi ponudili konstrukciju trodimenzionalnih modela, koji se mogu videti na različitim modelima avatara i iz više uglova. Jedna od najvećih prepreka modnom dizajnu i proizvodnji je procena pristajanja odeće da se sačuva, izloži i rekonstruiše na nove načine. Cilj ove studije je da se demonstrira kako je pomoću kompjuterskog programa Clo3D moguće uporediti jedan model ženske haljine na različitim avatarima i odabrati 3D virtuelni materijal sa različitim težinama tkanine bez potrebe za šivanjem stvarnog uzorka. Inženjeri i dizajneri mogu da koriste mnoge alate i funkcije koje pruža Clo3D da bi proizveli i izrazili 3D odeću na realističan virtuelni način.*

Ključne reči: *Clo3D, virtuelni, fit, avatar, drape.*

1. INTRODUCTION

Changes in the socio-cultural and economic fields have an impact on the textile and apparel industries. The fashion industry's increasing digitalization is in line with digital fashion, which can adapt quickly to changing consumer desires [1]. The traditional fashion sector is being transformed by digital solutions, which are made necessary by the digital economy [2]. The fashion business was compelled to undergo a digital revolution during the COVID-19 pandemic and other new social and economic conditions due to the rise of a noncontact community [3]. Consequentially, in the fashion sector, a dramatic shift in consumer behavior towards stronger online buying was recently noticed, and e-commerce is increasing at an unprecedented rate too [4]. On the other hand, in reality, a sizable portion of these online orders are returned, mostly for fit and size-related issues. Customer returns have increased significantly over the previous few years, with some categories seeing increases of up to 50% annually [5]. Regarding this, garment producers spend a lot of time trying to get approval for garment fit from their buyers. Therefore, E-fit simulation saves a substantial amount of time and eliminates the requirement for numerous sample approval iterations [6, 7]. Using digital patterns, the E-Fit Simulator creates "virtual cloth" that can be "sewn" on a computer and evaluated on a 3D fit model directly within the software. This allows the user to see exactly how the garment will look before sewing it as an actual sample.
Making cloth is an artistic procedure that entails shaping and cutting a piece of flat material to match the contours of a human body. Fit, which serves as a connection between design and production, is the most crucial element determining whether an item of clothing is eventually accepted or rejected. To ensure a good, customized fit, design drawings must consider the various forms and proportions of each customer [8] . The five main procedures that are typically included in clothing CAD systems are 2D pattern design and prepositioning, drape simulation, virtual sewing, and 2D or 3D design adjustment. Here, the technical difficulty of virtual fit resides in fabric simulation combined with human torso models that consider geometric contact points [9]. In the process of developing new clothing, it's crucial to prototype and evaluate fit. 3D garment simulation offers the ability to do away with the requirement for numerous physical prototypes. Thanks to advancements in 3D simulation technologies, 2D garment models may now be virtually fitted on human body simulations using specific apparel CAD software [10]. "3D pattern making" is the process of employing specialized software to create 3D digital clothing designs [11]. During this process, in a virtual setting, pattern parts must be created, modified, and altered. Compared to traditional 2D manual pattern building, 3D pattern manufacturing offers several benefits, such as enhanced visualization, quicker design iterations, and the capacity to model garment fit and behavior in a virtual setting [8]. It is anticipated that this makes clothing production more exact and productive in terms of time and cost savings of up to 30%, which benefits also in saving money [12]. As a result, there is less waste and more material used. Using fewer samples means fewer fabrics and other materials and a reduced carbon footprint too [13, 14]. Clo Virtual Fashion Inc. created Clo3D, a 3D program for the design and visualization of fabrics and

clothes. An excellent resource for assessing fit, seeing items in action, and experimenting with various fabric and color choices is the virtual design application Clo3D. Furthermore, patterns can be exported in several different formats [15].

According to Liu, Zhang, and Yuen [16], the assembly phase of clothing simulation cannot be based on a standardized model because fabrics are anisotropic throughout their entire surface and will drape differently depending on the cut, type, and components of the garment. The fabric must behave, look, and drape exactly like the actual sample to create a true-to-life virtual clothing sample, or digital copy, and all fabric data can be maintained in one central location [7]. The new virtual showrooms (Hugo Boss, PVH) [17, 18] created by businesses like Hatch and Pixelpool substitute a significant number of B2B samples and colorways with virtual samples backed by actual fabric samples. Studies on the usage of this virtual technology have identified variables such as clothing complexity, material visualization information, and virtual manikin type that could adversely affect the quality of 3D apparel simulation if they are not appropriately selected and imported [10].

The paper by T. Spahiu et al. [9] provides a short review of available CAD systems used by fashion designers. A garment simulation process is performed by using software for virtual design, Marvelous Designer and the used is gathered from the 3D body scanning system named Konica Minolta VIVID 910. In the study [19] 2D pattern for men's shirt are constructed using CAD software and and afterward 3D simulation is performed. Another study [20], through avatar personalization, aims to display the outcome of the human body on garment fit, by generating stress, strain, and fit maps. Pressure levels are shown in various color shades throughout the body simulation, allowing for subjective fit assessment. Objective fit valuation is made possible by numerical values shown on a scale bar. Specific apparel CAD tools handle parametric models and body scan avatars as solid objects. The computer-based textile models that are used to mimic clothing have a significant impact on the correctness of virtual fit [21]. The paper [22] present the final model of women's pants in 3D clothing simulation in different avatar poses, their fitting, fabric pressure and distorsion.

By analyzing pressure prediction accuracy and process practicability, Brubacher et al. assessed the viability of applying the virtual fit pressure map in a textile CAD program to anticipate pressures applied by sports and recreation compression clothes. Using these specific apparel CAD tools, several researchers have evaluated the accuracy of virtual fit simulations. They have compared virtual and real garment fit on mannikin [23] or human bodies [24, 25]. Although Lee & Park [24], noted issues with the realistic modeling of specific fit indicators, such as tiny fabric creases and draglines, they claimed that overall fit simulations were accurately done [24, 25]. The absence of technical construction data, like stitch tension and thread type, is probably the reason for this, which could lead to the discovery of less fit issues in virtual clothing compared to genuine clothing [25]. Heat maps have been used by other researchers [26, 27] to assess virtual garment fit in CAD programs, but none of them have made a straight examination between heat maps and actual garment fit. Test results from the Kaixuan at all [28] paper show that data-learning-based clothing fit assessment approaches have much higher prediction accuracy than conventional methods.

Understanding the actual state of manual pattern making and the use of specific 3D fashion design software in the textile industry is the main objective. The Clo approach was evaluated for some fit assessment possibilities, like fabric drape, creation of strain, stress, pressure, and fit maps for specific garments on different avatars.

2. EXPERIMENTAL PART

Using the Clo3D - specific apparel CAD/CAM computer program, this paper presents a comparison of one female dress model on different avatars. The initial step in the creation of clothing is garment design. Historically, clothing has been designed by hand using paper designs or fabric draped over a dress form. However, today's designers convey their ideas through technological tools. So, using Clo3D we can make an informed decision on the final garment, the distribution of contact points, and the pressure distribution range. Also, this software can fully satisfy several design needs, including fabric selection, fashion design, pattern creation, adjustment and alteration, presentation, and release.
Another crucial issue in virtual apparel is the selection of the avatar which can be taken from the computer library or to be adjusted by the designers (height, waist, chest, hip length etc). Therefore, in this research we have used the following avatars: Tall 36, Petite 36, Curvy 40 and Plus 48 for the same model of women`s dress.
The clothing size affects the physiological fit component, and tight or loose clothing is the most obvious sign of fit issues brought on by size. For better understanding of virtual garment fit, the Clo3D generate four types of maps: Stress, Strain, Pressure and Fit map. In this research, for the Petite avatar, all 4 types of maps have been created that clarify the fit of the clothes to the body.
The "Stress map" displays the range of color (eight colors) and figures that indicate the amount of pressure in the fabric per part because of a tight-fitting clothing. The blue represents no distortion (0.00 kPa), whereas the red indicates the highest stress (100 kPa). The precise location's kPa value displays when you click on a spot on an article of clothing. Stronger tension is applied from the avatar to the garment and vice versa when the kPa value is larger. The "Strain map" shows the percentage change in the garment's distortion rate as a result of external stress. Thus, the degree to which the garment is stretched while being worn is visible. There are eight colors available for this map: red denotes a distortion rate of 120 %, while blue denotes a distortion rate of 100%. More distortion between the 2D patterns and the 3D patterns (garment) on the avatar is indicated by a greater percentage number, and vice versa. Based on the distortion rate, we can adjust the 2D patterns as needed. The "Pressure map" is really like a Strain map. The strain map shows the amount of tension brought on by the pressure itself, whereas the pressure map depicts the pressure of the garment on the virtual model. Finally, the 3D garment's tightness is displayed on the fit map. The wearable region marked "Can't Wear" is red. "Tight areas" are displayed in yellow, and "Very Tight" appearances are visible in orange. Display Press Points: Display or conceal the points of contact between the avatar and the 3D garment. If the virtual model is appropriate for wearing this dress, it is determined by looking at the fit map.

Besides, the fit prediction and analysis, this program can provide a prediction of the drape of a needed fabric. To generate a digital fabric, this 3D virtual technology combines the physical and mechanical characteristics of the fabric with its weight. So, several materials are analyzed in this manuscript.

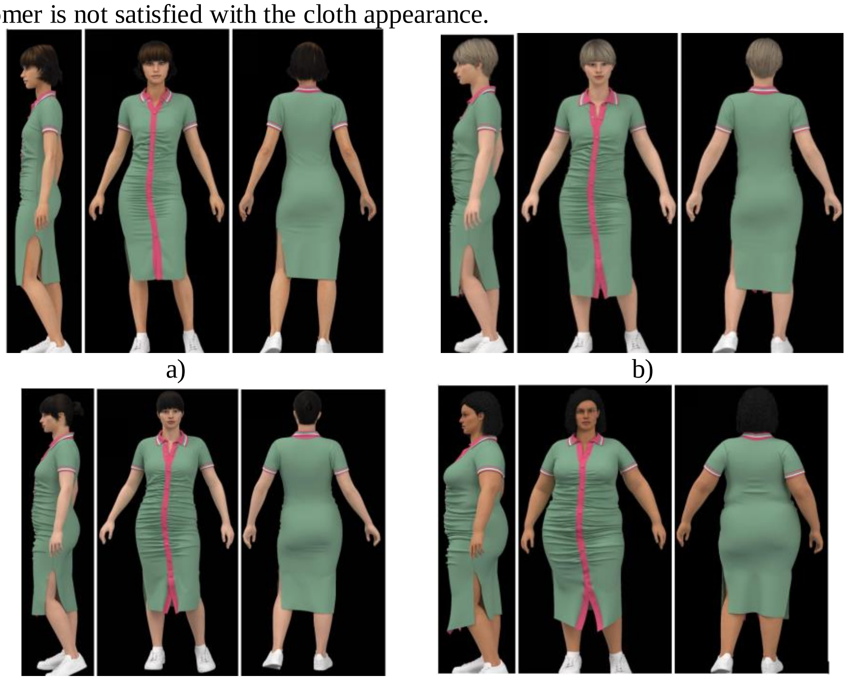
3. RESULTS AND DISCUSSION

3.1. Virtual fit of women's dress

Figure 1 represents the different types of avatars in the same dress pattern. All models are presented from the front, back, and side, to see the appearance of the dress more realistically.

This dress model has a length of several centimeters below the knees, except for the first avatar, where, due to its height, it reaches the length of the knees. The folds of the model on the front are less noticeable in the Tall and Petite avatars, while in the other two, they are more pronounced and extend to the side seams.

The difference between the avatars in terms of their height and other body measurements is evident. Using Clo3D it is obtained a visual presentation of how this model will fit clients with body dimensions like those of the corresponding avatar. This virtual presentation is highly accurate, so, in this way, we can avoid real (physical) sewing of the model if the customer is not satisfied with the cloth appearance.



a) b) c) d)

Figure 1: Dress model on four different avatars in front, back, and sides: a) Tall 36;

b) Petite 36; c) Curvy 40; d) Plus size 48

Thus, saving time and money are obtained. Specifically, the time and cost needed to make a real sample of the clothes is reduced, or it will be completely avoided.

For better comparison, Figure 2 presents all types of avatars.

Figure 2: Dress model on four different avatars, lateral side

Next, by using the possibilities offered by the Clo3D software, more precisely the different maps give insight into the fitting of the model to the body of the person/avatar. Figure 3 (3a-3e) shows all four types of maps, for the Petite avatar.

Stress map a) | Strain map b) | Pressure points c)

Fit map wrong d) Fit map right e)

Figure 3: a) Stress, b) Strain, c) Pressure, d) Fit maps wrong and e) Fit maps right for Petite avatar

The stress, strain, and fit maps that were produced during the simulation process of garment models over customized avatars allow for the evaluation of garment fit. So, based on the Stress map (Figures 3a and 3b) and the meaning of its colors, it is evident that this dress is pretty comfortable for the Petite avatar. Slight dress distortion is noticeable in the chest area, hips, and below them (lower thighs). Based on the generated Strain map, it can be concluded that 120% of garment distortion is evident on several points, like: along the armhole, the end of the sleeve, on the sides at the hips, and in the middle along the button fastening part. So, through the strain map, it can be seen how much the deformation of the garment fabric occurs after being worn on the virtual model. While, corresponding to the previous introduction, clothing pressure on the human body has more than the human body can bear (Figure 3c). The Fit maps (Figures 3d and 3e) present the tightness of the 3D Garment, and the model's clothing is divided into two colors. So, in this dress model, “tight areas” (yellow) are in the shoulder, around the chest, and along the upper and down part of the thighs. The “Can’t wear” area stands around the chest and middle part of the tights (red color). So, in the yellow area, can be made some modifications according to the effect achieved by the clothes. The red part must be adjusted, otherwise, this part of the clothing cannot be worn ordinarily that is, it would be less comfortable to wear.

3.2. 3D Virtual material draping with various fabric weights

Regarding the method of draping different types of materials, an analysis was made with the help of this program. According to the requirements of the program, some of the physical-mechanical characteristics of the fabrics are recorded, and their design is also recorded. In this way virtual twin of the real fabric can be generated. In Figure 4 several materials of different fibre composition and fabric weight are presented.

Figure 4: 3D draping of fabric with different weight

The way of drapery and the number of nodes can be evaluated. So, this activity can help in determinating which fabric is suitable for a particular model of clothing.

4. CONCLUSION

CAD is an inevitable element for the garment industry in order to deal with today's hard competition. 3D technology for clothing design and simulation are promising methods for producers and designers to promptly check the problems related to clothing fit and drape over personal avatars by prevent misunderstanding and subjectivity in representation. This is a new way to increase the cooperation between clothing designer, pattern maker and sellers to meet the client needs and to provide good-wearing clothes for the human body. In this research we have used the Clo3D program for simulation of garment fit on different avatar bodies. Based on the generated maps for the stress, strain, pressure, and fit points, we received information for the further needed modifications and pattern modelling to provide appropriate dress fitting. The program was also used and for drape simulation of several different fabrics. Of course, this software has many other possibilities which can be used. Beside the high accuracy of this kind of programs, still, future evolution in needed to be obtained soft tissue avatars and a more realistic fabric drapability and garment-body interface.

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