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가상아바타에 따른 가상의복의 비교평가

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Comparative Assessment of Virtual Garments using Direct and Manual Avatars

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Abstract

The purpose of this paper is to compare two avatars made using direct and manual methods and to evaluate the fit and appearance of two virtual garments on the direct and manual avatars. In this study, two subjects were measured by $[TC]^2$ body scanner and the avatars and virtual garments were created by OptiTex software. The direct avatar was made by the direct importation of 3D body scan data and the manual avatar was made by manual input from extracted body measurement. Two virtual garments in a tank-top were evaluated by distance, transparency, and stretch maps. In the results of comparing difference of the direct and manual avatars, the bust and back of the manual avatar are protruded slightly more than that of the direct avatar and the manual avatar is slightly larger dimensions at the bust, waist, abdomen, and hip area in the side view in case of subject 1 and 2. In the results of comparing difference of the fit and appearance of two virtual garments on the direct and manual avatars, in case of subject 1 and 2, the back of the virtual garment on the manual avatar are protruded more than that of the direct avatar. Also, the ease in the bust area of the virtual garment on the manual avatar with a projected bust area was smaller than that of the virtual garment on the direct avatar and the stretch of that of the manual avatar was also high in the bust area. The results of this study are expected to be used as basic information in the apparel industry using virtual try-on technology.

Key words: virtual avatar(가상아바타), virtual garment(가상의류), 3D body scan(3차원 인체스캔), fit(맞음새).

Ⅰ. Introduction

New technologies, including the commercialization of the 3D body scanner and the development of 3D shape reconstruction and 3D virtual garment simulation, are currently being used in web-based applications and information technology; the fashion industry is thus being digitalized on a full scale. Human shape modeling technology based on the 3D body scanner uses computer graphics and computer geometry and has developed such applications as 3D pattern CAD and 3D virtual garment simulation.

Technology involving 3D virtual human bodies

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and garments based on 3D body scanning is being used with increasing frequency in the apparel industry. With digital apparel technology, customers can view their virtual bodies in different sizes and shapes wearing virtual clothes and can determine whether or not the clothes are suitable. Programs to develop 3D virtual human bodies and garments include Browzwear V-stitcher, Optitex Runway, DressingSim, Asahi ADPS-3D, Fashionizer, Maya Cloth, Haute Couture 3D Studio, and NARCIS.[1)]

Three dimensional virtual garment technology is also being used increasingly often in other industries. Furthermore, many studies on 3D anthropometry, 3D virtual human bodies, and 3D virtual garments are being conducted.

The virtual human body based on 3D anthropometry has conventionally been created by two methods: (1) the direct avatar, using 3D body scan form (OBJ file), and (2) the manual avatar, using the body measurement of MEP file. The output point cloud image that is created with the raw point cloud data (PCD) of a 3D body scan is called "scanned me" represents the actual human body as it is.[2)] However, the image is not always perfect as data from the scanner often includes noise data. This data needs to be reconstructed before processing it further to create the 3D avatar. The virtual avatar directly reconstructed from the 3D body scan form is called "virtual me."[3)] Whereas, the virtual avatar manually made from the body measurement is called "virtual twin."[4)] In the manual virtual avatar method, the dimensions of the existing virtual avatar in the virtual software are modified. Many studies have been conducted on direct and manual virtual avatars.[5~13)]

Recently, 3D virtual garments have been applied to 3D virtual bodies so that the fit and appearance of clothing can be determined without the clothes having to be made or tried on. Virtual garment tech-

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nology is categorized into two methods: the development of the 3D avatar in the 2D plane, and the 3D virtual try-on using the 2D flat pattern.[14] In the first method, the development of the 3D virtual avatar in the 2D plane includes studies of pattern manufacturing by developing the spatial shape of 3D human skin surfaces, cutting them in 2D planes[15,16] and placing the basic apparel patterns on the 3D virtual avatars and developing them in 2D planes as if they were draped.[17,18] In the second method, 2D flat patterns are created using apparel CAD software; then, they are virtually sewn into 3D patterns, which are subsequently simulated on the 3D virtual avatars.[19~21]

Many studies on virtual avatars and garments have addressed the draping characteristic of virtual fabric,[22~24] but the fit and appearance of virtual garments on virtual avatars have not been studied sufficiently. Internet fashion product sales require that customers be able to view their avatars wearing virtual clothes to enable them to determine if the clothes will look good on them. Therefore, the success of Internet fashion product sales will depend on whether customers can determine which clothes are suitable by trying on the virtual garments using customer avatars having precise body sizes and shapes using virtual simulation technology.[25,26]

In this study, the fit and appearance of virtual garments tried on direct and manual virtual avatars were compared in order to propose a virtual avatar and garments suitable for the apparel and fashion industry.

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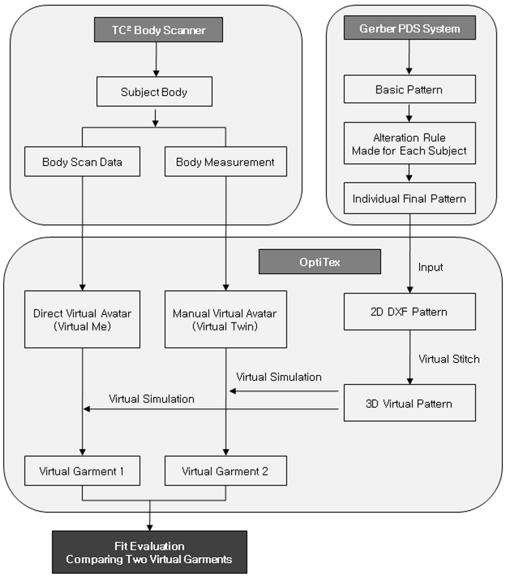
Ⅱ. Methods

In this study, the fit of virtual garments on a direct and manual virtual avatar was evaluated using the OptiTex software system. 〈Fig. 1〉 shows that the methodology for this study was created to evaluate the fit of two virtual garments on the direct and the manual virtual avatars.

1. Virtual Avatars

In this study, $[TC]^2$ body scanner was used to measure the subject's body and OptiTex software system was used to create the virtual avatars and garments. The direct virtual avatar (virtual me) was created by using the subject's 3D body scan data and the manual virtual avatar (virtual twin) was created by using the subject's body measurement. For the direct virtual avatar (virtual me), the reduced body data (*.rbd) made from the $[TC]^2$ body scanner was transferred to an OBJ format file (*.obj) by a morph tool of the NX16 software system and the OBJ format data were directly imported into OptiTex software. Therefore, the direct virtual avatar has the body measurement and shape of the subjects and it is similar to the subject's real body, because their body scan data were directly imported to made the virtual avatar.



〈Fig. 1〉 Methodology for Fit Evaluation of Virtual Garment

For the manual virtual avatar (virtual twin), the subject's body measurement extracted by a measurement extraction profile (.MEP file) of the $[TC]^2$ body scanner were manually input into the body measurement of the OptiTex's original avatar. However, the manual virtual avatar is a little different to the subject's real body because the body shape wasn't applied to the manual virtual avatar.

Finally, the image of the manual virtual avatar (virtual twin) was overlapped on the direct virtual avatar (virtual me) and the differences (DF) of the sizes between two different virtual avatars were measured in the chest, bust, waist, and abdomen areas.

2. Virtual Garments

In this study, a tank-top was selected as an experimental garment. For virtual garment simulation, the DXF pattern files (a 2D pattern) made by Gerber AccukMark were imported into OptiTex software. The 2D basic pattern in a standard size 8 (ASTM 5585) was made and graded by using the Gerber AccuMark PDS system. An alteration rule was created and applied to make patterns that fit individual consumers. The individual patterns made using the alteration rule were exported into DXF AAMA format files and these DXF files were imported into OptiTex software. Then, the 2D patterns were sewn by using a 3D virtual stitch tool and the 3D garment developed from the 2D pattern was simulated on the 3D avatar. 〈Fig. 2 (a)〉 illustrates the positioning of pattern pieces around the avatar; 〈Fig. 2 (b)〉 shows the particle simulation process in progress; and 〈Fig. 2 (c)〉 illustrates the completed virtual garment simulation.

The virtual garments made by this process were simulated on the direct and manual virtual avatar. Finally, the fit and appearance of two virtual garments on the direct and manual virtual avatar were

(a) Beginning of Simulation (b) Simulating (c) Simulation Complete

〈Fig. 2〉 Simulation Process for Tank Top

evaluated by distance, transparency, and stretch maps.

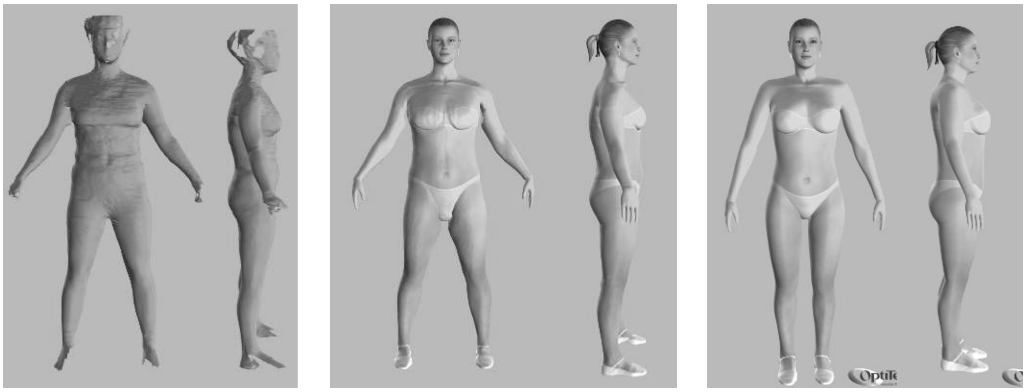
Ⅲ. Results and Discussion

1. Comparison of Direct Avatar and Manual Avatar

1) Subject 1

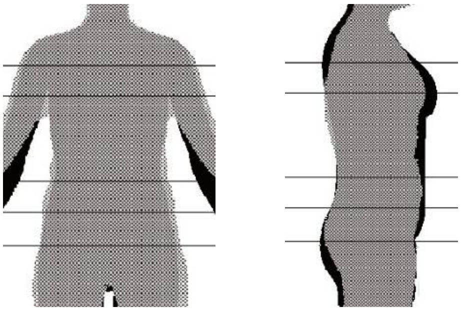
〈Fig. 3 (a)〉 displays the real body image (scanned me) captured by the $[TC]^2$ body scanner, 〈Fig. 3 (b)〉 presents the direct avatar image (virtual me) created through conversion from $[TC]^2$ body scan data, and 〈Fig. 3 (c)〉 displays the manual avatar image (virtual twin) created by the body scan measurements. As shown this figure, the direct avatar is similar to the real body and the manual avatar is different to the real body comparing their body shapes.

To compare the direct avatar and manual avatar, the image of the manual virtual avatar (virtual twin) was overlapped on the direct virtual avatar (virtual me) (Fig. 4). And then the differences (DF) of the sizes between two virtual avatars of subject 1 were compared in the front and side view. The different



(a) Real Body (b) Direct Avatar (c) Manual Avatar

〈Fig. 3〉 Real Body and Virtual Avatars of Subject 1



(a) Front View (b) Side View
Gray: Direct Avatar, Black: Manual Avatar

〈Fig. 4〉 Overlapped Images between Direct and Manual Avatars of Subject 1

sizes between the direct and manual virtual avatar were measured in the chest, bust, waist, abdomen, and hip.

〈Fig. 4〉 shows the overlapped images between direct and manual virtual avatars of subject 1.

In the front view, the waist shape is straighter in the direct avatar and more curved in the manual avatar. Comparing the different size between two avatars, the manual avatar (virtual twin) is slightly smaller dimensions (such as right bust DF= 0.0 inch, left bust DF= 0.0 inch, right waist DF= −0.7 inch, left waist DF= −0.7 inch, right abdomen DF= −0.7 inch, left abdomen DF= −0.7 inch, right hip DF= 0.0 inch, and left hip DF= −0.5 inch) than the direct avatar (virtual me).

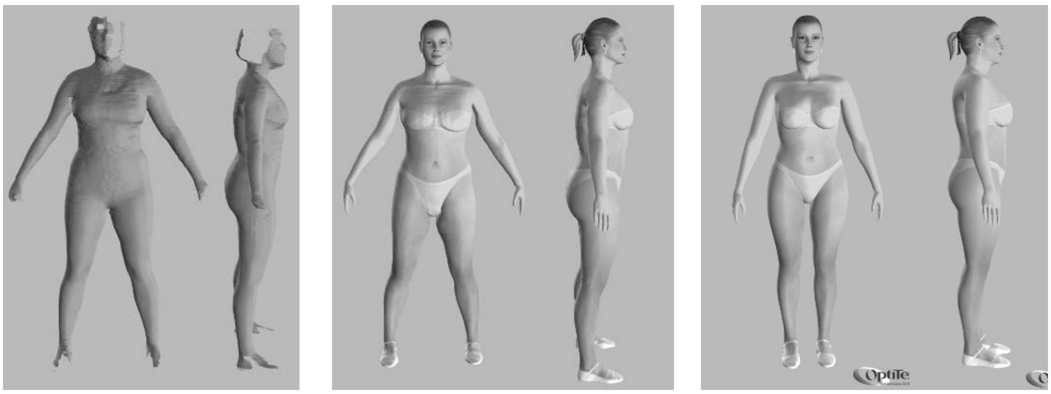
In the side view, the bust and back of the manual avatar are protruded slightly more than that of the direct avatar. Comparing the different size between two avatars, the manual avatar (virtual twin) is slightly larger dimensions (such as back chest DF= +0.9 inch, front chest DF= +0.3 inch, back bust DF= 0.0 inch, front bust DF= +1.2 inch, back waist DF= +0.1 inch, front waist DF= +0.8 inch, back abdomen DF= 0.0 inch, front abdomen DF= +0.1 inch, back hip DF= +0.6 inch, and front hip DF= 0.0 inch) than the direct avatar (virtual me).

2) Subject 2

〈Fig. 5〉 presents the real body image (a), the direct avatar image (b), and the manual avatar image (c) with subject 2. The image of the manual virtual avatar was overlapped on the direct virtual avatar and the differences (DF) of the sizes between two virtual avatars of subject 2 were compared in the front and side view.

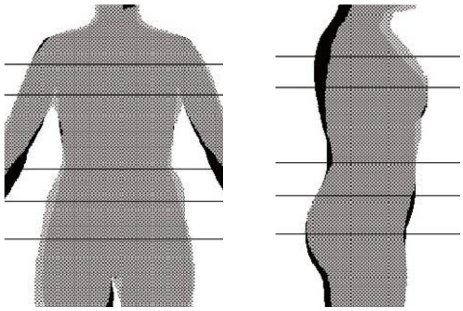
〈Fig. 6〉 shows the overlapped images between direct and manual virtual avatars of subject 2.

In the front view, the direct avatar has a protrusive shape at high hip and hip and the manual avatar doesn't have a protruded shape. The back of



(a) Real Body (b) Direct Avatar (c) Manual Avatar

〈Fig. 5〉 Real Body and Virtual Avatars of Subject 2



(a) Front View (b) Side View

Gray: Direct Avatar, Black: Manual Avatar

〈Fig. 6〉 Overlapped Images between Direct and Manual Avatars of Subject 2

the manual avatar are protruded more than that of the direct avatar and the manual avatar has a backward-leaning posture. Comparing the different size between two avatars, the manual avatar (virtual twin) is slightly smaller dimensions (such as right bust DF= +0.1 inch, left bust DF= +0.2 inch, right waist DF= −0.1 inch, left waist DF= −0.5 inch, right abdomen DF= −0.7 inch, left abdomen DF= −0.7 inch, right hip DF= −0.4 inch, and left hip DF= −0.4 inch) than the direct avatar (virtual me).

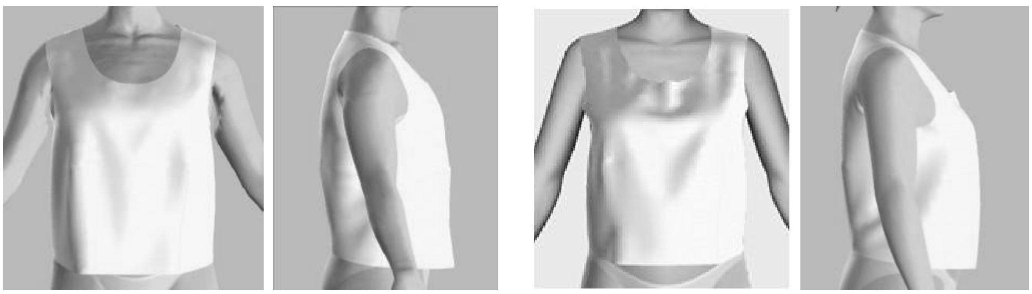
In the side view, the back of the manual avatar are protruded more than that of the direct avatar. The manual avatar bends its upper body backwards. The reason is that the body measurements are manually input into the OptiTex's original avatar for making the manual virtual avatar and it has the body shape of the original avatar. On the other hand, the 3D body scan data are directly imported for making the direct virtual avatar and it has the body shape of the real body.

Comparing the different size between two avatars, the manual avatar (virtual twin) is slightly larger dimensions (such as back chest DF= +1.8 inch, front chest DF= −1.8 inch, back bust DF= +1.2 inch, front bust DF= −0.8 inch, back waist DF= +0.9 inch, front waist DF= 0.0 inch, back abdomen DF= 0.0 inch, front abdomen DF= +0.1 inch, back hip DF= +0.1 inch, and front hip DF= +0.1 inch) than the direct avatar (virtual me).

2. Comparison of Two Virtual Garments on the Direct and Manual Avatars

1) Subject 1

〈Fig. 7〉 shows the virtual garment on the direct avatar and the virtual garment on the manual avatar for subject 1. As shown in the side view in 〈Fig. 7 (b)〉, the bust of the virtual garment on the manual avatar was more projected than that of the virtual garment on the direct avatar, and the center front silhouette of the virtual garment on the manual avatar created a perpendicular angle on the whole. Meanwhile, the center front silhouette of the virtual garment on the direct avatar was diagonally inclined. This seems to have been because the bust of the manual virtual avatar projected +1.2 inch (front bust



(a) Virtual Garment on Direct Avatar (b) Virtual Garment on Manual Avatar

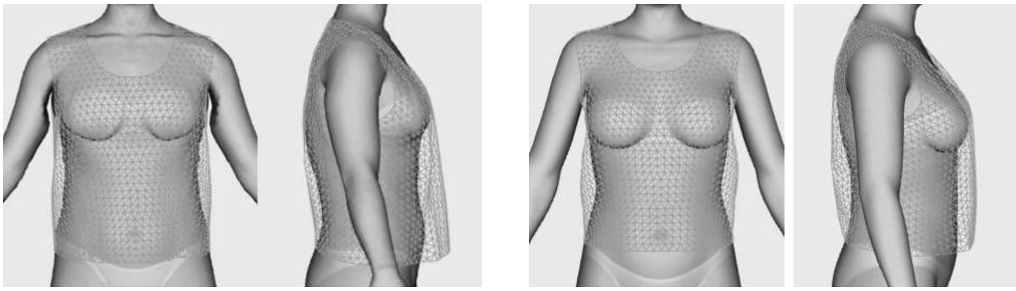
〈Fig. 7〉 Appearance Image of Virtual Garments - Subject 1

DF) more than that of the direct virtual avatar.

The difference in the virtual garment shapes according to body shape was also examined, as shown in 〈Fig. 8〉, which illustrates the ease between transparent virtual garments and virtual avatars. As shown in the front view in 〈Fig. 8 (b)〉, the ease of the virtual garment on the manual avatar (b) at the bust was smaller than that of the virtual garment on the direct avatar (a). In the side view, the ease of the virtual garment on the manual avatar (b) at the front waist and front abdomen is smaller than that of the virtual garment on the direct avatar (a). It seems that reason is that the front waist of the manual avatar is larger dimension (DF= +0.8 inch) than that of the direct avatar and the front abdomen of the manual avatar is larger dimension (DF= +0.1 inch) than that of the direct avatar.

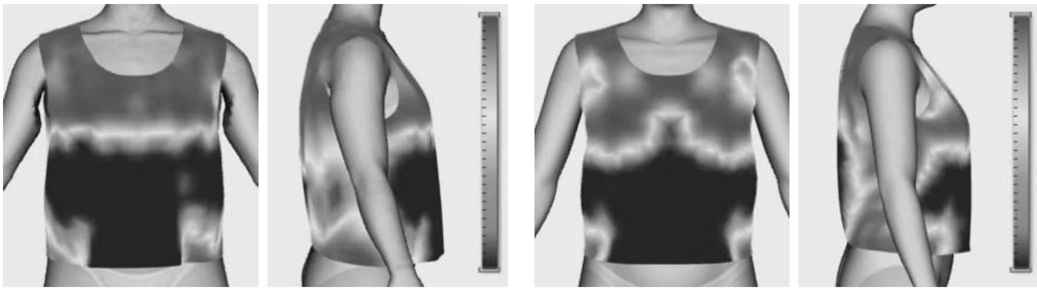
〈Fig. 9〉 shows a map of the distance values between virtual avatar and garment. In this figure, the gray color indicates a low distance value and the black color indicates a high distance value. The distance values ranged from 0.24cm to 4.00cm in the case of the virtual garment on the direct avatar, and from 0.23cm to 4.00cm in the case of the virtual garment on the manual avatar. The gray color area was concentrated in the protruding bust area in the case of the virtual garment on the manual avatar (Fig. 9 (b)), which showed that the distance (or ease) was small in that area.

〈Fig. 10〉 shows the stretch, that is, the amount of fabric expansion in two virtual garments on the direct and manual avatars. In this figure, the bright color (ex. white) indicates a low stretch value and the dark color (ex. black color) indicates a high stretch value. The stretch values ranged from 1.11% to 0.45% in the case of the virtual garment on the direct avatar and from −1.42% to 0.25% in the case of the virtual garment on the manual avatar. In 〈Fig. 10〉,



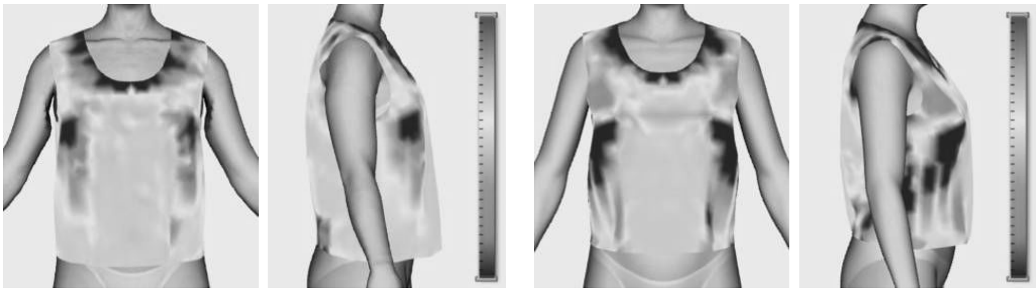
(a) Virtual Garment on Direct Avatar (b) Virtual Garment on Manual Avatar

〈Fig. 8〉 Transparency of Virtual Garments - Subject 1



(a) Virtual Garment on Direct Avatar (b) Virtual Garment on Manual Avatar

〈Fig. 9〉 Distance of Virtual Garments - Subject 1



(a) Virtual Garment on Direct Avatar　　(b) Virtual Garment on Manual Avatar

〈Fig. 10〉 Stretch of Virtual Garments - Subject 1

the stretch in the bust area of the virtual garment on the manual avatar is darker than that of the virtual garment on the direct avatar. This indicates that the stretch value in the bust of the virtual garment on the manual avatar is higher. It seems that reason is that the front bust of the manual avatar is larger dimension (DF= +1.2 inch) than that of the direct avatar.

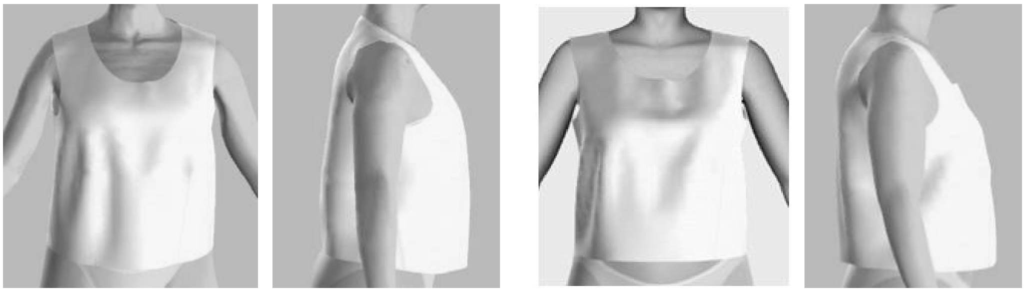
These results correspond to previous test results that found that the ease of the virtual garment on the manual avatar in the bust area was smaller than that of the virtual garment on the direct avatar (Figs. 8 and 9). Based on the principle that a smaller ease leads to a higher stretch, these stretch results were closely correlated with the ease results.

2) Subject 2

〈Fig. 11〉 shows the virtual garment on the direct avatar and the virtual garment on the manual avatar for subject 2. 〈Fig. 12〉 shows transparent virtual garments and the ease between the virtual avatar and garment. 〈Fig. 13〉 presents a map of the distance values between virtual avatar and garment. The distance values ranged from 0.23cm to 4.00cm in the case of virtual garment on the direct avatar, and from 0.21cm to 4.00cm in the case of virtual garment on the manual avatar.

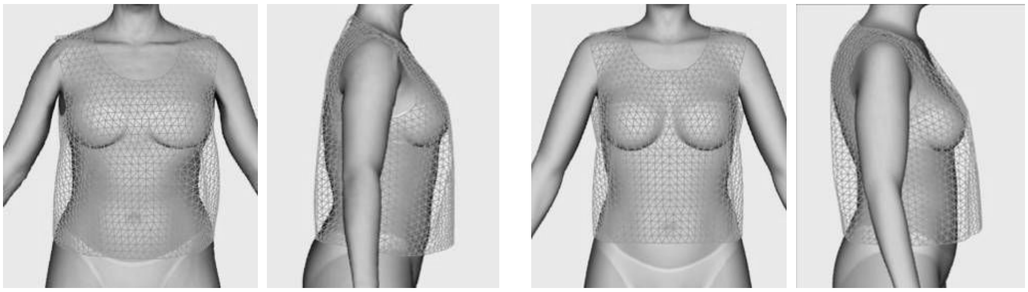
In virtual garment on the manual avatar (Fig. 13 (b)), the gray color area was roundly and prominently concentrated in the bust area and the back area (from neck to syce depth). It means that the ease of these areas was small in virtual garment on the manual avatar. In virtual garment on the manual avatar, the back area was more projected, and the front center line was more inclined than in virtual garment on the direct avatar.

This seems to have been because the manual virtual avatar of subject 2 had the scye depth area (from the cervical vertebra to the scye upper edge)



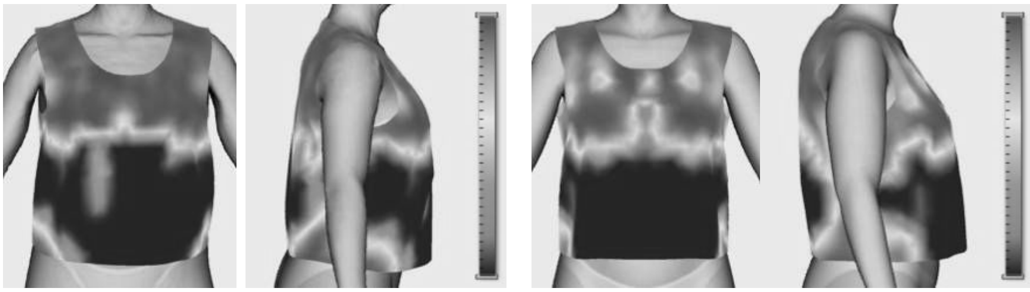
(a) Virtual Garment on Direct Avatar　　(b) Virtual Garment on Manual Avatar

〈Fig. 11〉 Appearance Image of Virtual Garments - Subject 2



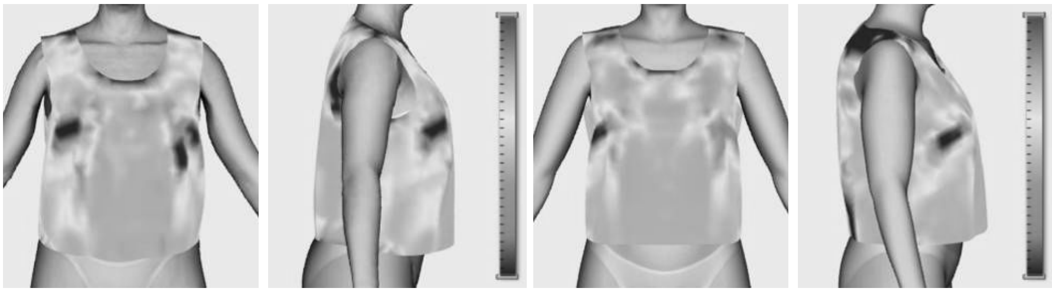
(a) Virtual Garment on Direct Avatar (b) Virtual Garment on Manual Avatar

〈Fig. 12〉 Transparency Map of Virtual Garments - Subject 2



(a) Virtual Garment on Direct Avatar (b) Virtual Garment on Manual Avatar

〈Fig. 13〉 Distance Map of Virtual Garments - Subject 2



(a) Virtual Garment on Direct Avatar (b) Virtual Garment on Manual Avatar

〈Fig. 14〉 Stretch Map of Virtual Garments - Subject 2

was more projected and angled backward than that of the direct virtual avatar.

〈Fig. 14〉 shows the stretch map images of two virtual garments on the direct and manual avatars. The stretch values ranged from −1.13% to 0.33% in the case of virtual garment on the direct avatar, and from −2.08% to 0.12% in the case of virtual garment on the manual avatar. These results also revealed that the ease in the scye depth area of virtual garment on the manual avatar (from the cervical vertebra to the scye upper edge) was small, so that the stretch value was high.

These results indicated that the fit and appearance of the virtual garments on the direct and manual virtual avatars differed. The ease and stretch of virtual garments varied according to the body shapes of the virtual avatars. This suggests that the manual virtual avatar has different measurements and shapes than those of the direct virtual avatar, and that the fit and appearance of the virtual garment on the direct avatar on the manual avatar may look different from those of the virtual garment on the manual avatar on the direct virtual avatar.

Ⅳ. Conclusion

In this study, 3D virtual garments were simulated on direct and manual virtual avatars. The direct virtual avatar was made by using 3D body scan data and the manual virtual avatar was made by using body measurements. The 2D pattern was imported into Optitex software and was sewn by virtual stitch to make the 3D pattern. The 3D virtual garment made through this process was simulated on the direct and manual avatars. And then, the fit and appearance of two virtual garments were evaluated by distance, transparency, and stretch map.

The results of this study are summarized as follows.

First, in case of subject 1, the bust and back of the manual avatar are protruded slightly more than that of the direct avatar and the manual avatar is slightly larger dimensions at the bust, waist, abdomen, and hip area in the side view. In case of subject 2, the back of the manual avatar are protruded more than that of the direct avatar and the manual avatar is slightly larger dimensions at the bust, waist, abdomen, and hip area in the side view.

Second, in the case of subject 1, the ease in the bust area of the virtual garment on the manual avatar with a projected bust area was smaller than that of the virtual garment on the direct avatar. The stretch of the virtual garment on the manual avatar was also high in the bust area.

Third, in the case of subject 2, a more projected back (from neck to syce depth) and a more diagonal front center line were found in the virtual garment on the manual avatar with a more projected back and a backward-leaning posture than in virtual garment on the direct avatar.

The results revealed that the fit and appearance of the virtual garments on the direct and manual virtual avatars differed. This indicates that it's difficult to evaluate the fit and appearance of clothes, because those of the virtual garments are different according to customers try on the direct or manual virtual avatar in online shopping. With the current virtual try-on technology, the direct virtual avatar created from 3D body scan data of the customers ensures more precise fit and appearance in wearing virtual garments. It has an asymmetric body shape, however, and cannot simulate different human poses, so there remain technical problems to solve. The manual virtual avatar can accommodate symmetric body shapes and different poses; however, the entry of 2D human body measurements cannot support various real body shapes.

This study evaluated the fit and appearance of virtual garments on virtual avatars, which are often used in online apparel shopping using virtual garment simulation technology. In light of the issues that were identified, it is clear that 3D virtual avatar and virtual garment technology needs further development in the future.

In future studies, the real and virtual garment try-on needs to be comparatively evaluated by using various body shapes and garment items, in order to improve the applicability of the 3D virtual try-on system.

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