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Effects of 3D Virtual "Try-On" on Online Sales and Customers' Purchasing Experiences

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ABSTRACT The advancement of the Internet and technology has made it possible to purchase and use different types of products and services online instead of offline. In particular, as the scale of online shopping malls is rapidly increasing, new functions have been tried and introduced to compensate for the limitation of not being able to directly wear clothes in an online mall. Among them, 3D virtual try-on is an innovative service and its technology is being advanced with continuous interest. Technological advances and interest in 3D virtual try-on have led to a variety of related studies. Most previous studies on virtual try-on have been conducted on the virtual fitting technology from the perspective of making clothes, or the effects and customer behavior from the customer perspective. However, there has been no research based on actual data of customers using 3D virtual try-on to show how virtual try-on affects sales. Therefore, this study understands the fundamental meaning of virtual 'try-on' as a customer experience and examines the effects of 3D virtual try-on on online sales. We create a 3D body model complemented by adding more diverse body shapes and sizes, and investigate the effects of virtual try-on on online sales through actual data. In addition, qualitative data including interviews are used to complement and interpret the results. The results show that virtual try-on affects the sales results: the average sales per customer increased by 14,000 won (13USD). The most important finding is that the return rate decreased by 27% by filtering out incorrect sizes and fits. Virtual try-on may very well replace physical fitting rooms. This study presents an advanced technology of 3D virtual try-on and shows that virtual try-on is an effective tool to boost sales and decrease customer's returns in a case study of women's casual L brand.

INDEX TERMS Virtual try-on (VTO), 3D clothes digitization, customized body, customer experience, online sales.

I. INTRODUCTION

During the past decade, interest has grown in three-dimensional (3D) virtual 'try-on,' and has been recognized for its value as an effective aspect of customer experience. Its original intent was to help customers check out size and fit virtually, but it has become an enjoyable customer experience. Since virtual try-on can help customers filter out incorrect sizes and fits to solve the thorny problem of customers' inability to wear a garment online, it is very useful in online malls. In addition, a mix-and-match service can provide hedonic value, and 3D virtual try-on has become a significant feature of online malls. The development of 3D virtual try-on has led to hopes that it helps boost online sales, which has emerged as a compelling retail channel for apparel sales. According to Smallbizgenius (2019), online retail sales grew 23.3% over 2017 [1]. The online retail sales are expected to account for 13.7% of global retail sales in 2019. Also, the top online purchasing categories in 2018 were fashion at 61% [2]. To increase online sales, Kolon FnC developed innovative projects in previous years to succeed in the competitive omni-channel market environment [3]. Its innovations consist of several information technology projects to attract customers, establish relationships with customers, and increase online sales.

Two critical issues in online sales are the high return rates and consumers' hesitancy to purchase apparel. Previous research [4] have identified online customers reluctance to

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buy apparel because they were not able to wear them to assess the style. In addition, they could easily return a product if it happens to be the wrong size or fit. Thus, our initiatives have focused on providing relevant, detailed product information and new experiences with 3D virtual try-on to attract more customers and help them with their decision. Before the advent of our 3D virtual try-on service, our online customers only had 2D model pictures and garment size information to make a purchase decision leaving it to their imagination weather the apparel will fit. It suits means that the customer likes the style, and 'it fits' means that the garment fits the customer's body well. Since online customers are unable to wear a particular garment and do not know whether it looks good, they are reluctant to purchase a garment and tend to return garments for the wrong size and fit. To solve this problem, our project concentrates on a 3D virtual model with a try-on and mix-and-match feature. With this feature, online customers can make a virtual model of their own shape and size and 'try on' garments by looking at images of the outfit. A customer can then decide whether a garment looks good and fits well. In addition, a customer can mix and match garments to coordinate a style.

In this study, we use the term virtual try-on (VTO) instead of virtual fitting because even if a garment shows fit virtually, readers might be confused for the following reasons. In the fashion supply chain, fit could be checked not only during the sales/retail process but also at the designing process. First, during the design process, a designer checks the fit to illustrate his or her design intention aesthetically, and a technical designer checks the fit to ensure that the garment fits well on the body and to fix the patterns to construct well. A pattern professional must then fix the garment patterns according to the fit guide of the designer and the technical designer. Second, during the sales/retail process, a customer checks out the fit, which helps to make a decision on purchasing apparel. The replacement of physical fitting with virtual fitting would save the costs of making samples in the design process and help customers to buy without having to wear an actual garment. In this study, we deal with virtual fitting during the sales process and use the term VTO.

Most previous studies on virtual fitting or virtual try-on (VTO) have focused on technology [5]–[7], the effects and effectiveness [8]–[11], and consumer behavior [12]–[14]. These were either studied on its technology in design chain from the point of view of making clothes, or studies on effects and behavior from the point of view of customers. However, no research has been conducted to investigate the effect of 3D virtual try-on on sales with actual data. Therefore, this study is to examine how 3D virtual try-on affects the sales results. Then, we explain customers' experience of 3D virtual try-on service by interviewing a group of users of a 3D virtual try-on service. In this study, we explain in detail the advanced information technology of virtual try-on and analyze the effects of information technology on sales in terms of the relationship between customer experience and real sales results. The purpose of this study is to measure the effects of customer's virtual try-on on the actual sales and to explain the meanings of this customer experience and how it might create value for online customers. Therefore, we developed the following research questions:

RQ 1. To what extent is the virtual try-on experience able to affect sales and consumer behaviors?

RQ 2. What are the values and meanings of virtual try-on?

This study is organized as follows. First, the relevant literature about virtual fitting is outlined and the gaps from our study and others are explained. Next, the research design is explained and the key findings are discussed. Finally, the implications and limits of our research are discussed.

II. LITERATURE REVIEW

A. VIRTUAL TRY-ON (VTO) AT RETAIL/SALES CHAIN

Virtual try-on (VTO) is a new technology used to help customers try on and mix and match apparel without a fitting room. In the retail environment, U.S. department stores such as Macy's, J.C. Penney, and Nordstrom's applied new virtual fitting room technology in the early 2010s to improve their customers' retail experiences. It appeared when conventional shops were in crisis because of consumers' shift to online retailers [15] VTO technology has been adopted because it has many advantages in both retail channels. At traditional retailers, many consumers feel reluctant to talk about their body size and shape with the salesperson, and at online retailers, consumers are unable to wear the apparel physically. VTO can then provide consumers with impersonal interaction with a virtual model of the customer's own body that replaces the actual try-on, so that it can conveniently provide size and fit guide. It can solve the problem of incorrect size and fit, which is a common reason for consumer returns. VTO data are significant for retailers because they can explain consumer insights. Because digital simulations can track consumers' preferences in buying clothes, retailers can use this information to predict sales. In addition, because VTO tends to increase consumer satisfaction, retailers can use this tool to increase consumer loyalty. Recently, consumers can try clothes on a model more similar with them by using personalized 3D model using their personal information when they purchase clothes online [16]. In addition, they can check the wearing sensation not only from the front but also from the back and sides with the use of various angles. Despite these advantages, VTO has shortcomings, including poor simulation of the tactile sense or texture of the fabric. So far, VTO has been developed with advanced technology including Microsoft's Kinect, 3D scanning technology, physical simulation with machine learning techniques, GPU-based real-time cloth simulation, image-based virtual try-on network, multi-pose guided virtual try-on network, and better size recommendations [8], [17]–[19]. Recent technology has focused on realistic simulation [20]. Sun *et al.* (2019) proposed a novel image-based virtual try-on network, which could maintain the structural consistency between the generated image and original image by human parsing

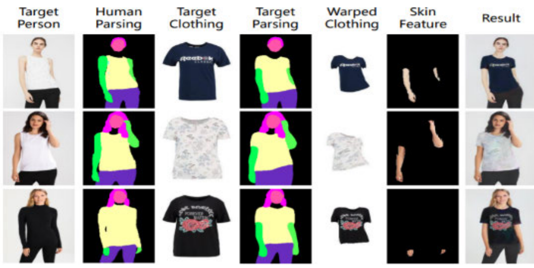

FIGURE 1. Image-based virtual try-on network [42].

(see Figure 1) [19]. Boonbrahm *et al.* [5] researched realistic simulation technology of 3D dress and the physical properties of fabrics by varying parameters. We can thus tell the kinds of fabrics used by looking at the appearances of fabric stretching stiffness, bending stiffness, damping, friction, collision, and gravity. This simulation is possible with a 3D game engine, Maya, and Microsoft's Kinect2.

VTO technology consists of making a virtual body model from the customer's own body size, 3D garment modeling, and interactive try-on and mix-and-match of garments [21] Many studies explain the method of making a virtual body by scanning or measuring the customer's body. 3D garment modeling is done from 2D computer-aided design (CAD) flat patterns or from 2D garment photos. Because the creation of 3D garments has been developed using 2D garment photos, VTO can be easily implemented to build a virtual showroom for people who do not have 2D CAD patterns [22] VTO has clearly begun to revolutionize the retail scene with advanced technology such as multiple-sensor 3D scanners, augmented reality, and simulations. Also, making a good virtual fitting room relied on two important factors, the method of detecting the user's body size, position, and movement, and the method of displaying the virtual garments superimposed in the user's body [23]. In addition to VTO, social networking features allow customers to send photos and receive quick feedback [24] According to the research examining VTO's results, it helps to boost sales and decrease returns [25].

Previous studies have concentrated on modeling technology and realistic simulations. They evaluated that VTO technology overall provides adequate visibility to replace physical try-on and to check the size and fit for customers. However, rather less attention has been paid to the effects of VTO in relation to retail sales.

B. VIRTUAL FITTING IN THE DESIGN CHAIN

Fitting is the process by which designers and technical designers check the garment details, size, and fit of the sample on a model body and seeks a final pattern by iteratively fixing the sample shape. Virtual fitting is the visualization of a sample garment to tune in the fits virtually. In a retail environment, virtual fitting has become an important aspect of the design process because it can replace some of the samples needed for fitting and can reduce production costs. As an example, the U.S manufacturers Target, Kohl's, and Levi's have adopted 3D simulation technology to check fit in the garment sample-making process because of its benefits of speed and lower total production costs, and its use is likely to expand in the near future [26]. Retailers understand the weak points of virtual fitting, which is insufficient to visualize fits and garment shapes from the perspectives of designers and technical designers to replace the physical fitting process, but several U.S. manufacturers plan to use virtual fitting tools in sample production for cost reasons [6].

In general, virtual fitting technology is similar to visualization of the garment, yet it differs from VTO in two ways. First, virtual fitting is usually deployed on apparel patternmaking CAD systems to assemble 2D patterns of a garment to drape on a 3D body to shows how it fits on the body. Several virtual fitting CAD programs have been developed by the pattern CAD companies, including Optitex (Israel), Gerber Scientific (US), Lectra (France), Technoa (Japan), Assyst (Germany), and CLO Virtual Fashion (Korea) [27] Because the purpose of virtual fitting is to tune in and complete the patterns to reach a quality garment, the technology is developed by pattern CAD companies, and the 3D geometric rendering is from 2D CAD pattern images. Second, virtual fitting requires more advanced technology than VTO, because virtual fitting is used to check the fit and fine tune a garment when making a sample. If virtual fitting can replace conventional sample fitting during the design process, it would be advantageous to save sample-making time and total production cost [28]. For clothing retailers, virtual fitting has become a favorite technology for investment. To replace actual fitting, virtual fitting simulation must illustrate silhouette, detail sizes, fits, ease, realistic fabric folds/drapes, and fabric color/texture that looks the same as the actual sample [7], [9]. For example, Dongdaemun provides stores sponsored by Seoul with a virtual fitting service of producing clothes from virtual clothes designed by customers using 3D technology within 24 hours. This service is called 'Within 24.' Consumers choose basic design samples (design, fabric, pattern, etc.) from look books of the 3D cloth manufacturing software and try the samples on their avatars to make real clothes.

Even though visualization technology is advanced and overall adequate to represent fits, current virtual fitting is generally ineffective and cannot replace a designer/technical designer's fitting process of the actual sample. Studies have investigated the similarities of actual garments and virtual 3D pants, skirts, jackets and other items. One study of pants explained that the waist location, ease, and stress folds of virtual pants differed greatly from actual sample pants. Another study concluded that the overall accuracy of virtual fitting was good but insufficient for designers to replace physical fitting [6]. Another study evaluated that visualization of size variations was enough for viewers to perceive size differences, which means that this size visualization could be used in the fit analysis of grading samples. As a result, manufacturers can replace fit analysis of size grading samples and need not make multiple samples in various size grades or hire multiple fit models of various sizes [10]. However, virtual fitting

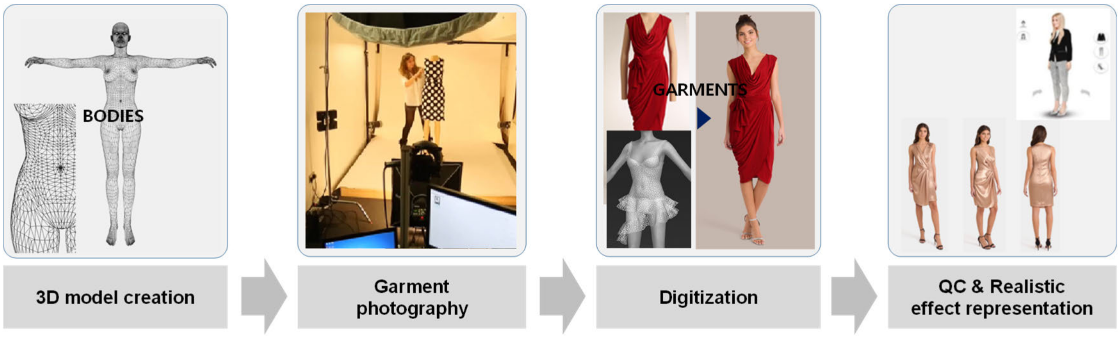

FIGURE 2. Process of 3D body modeling, cloth simulation, and customized body modeling.

is limited and has issues that must be addressed before virtual technology can be completely trusted as a visual fit analysis tool.

Several researchers [11], [29], [30] have evaluated the fit and style of skirts by comparing similarities between the real fit and the virtual fit. They found that the accuracy of visualization—for example in terms of shirring, frill, fit point placement, and fabric properties—is insufficient for use by designers and technical designers. In these studies, investigated the fit of various items and concluded that it was generally possible to visualize overall fits, but that its limits prevent it from replacing actual fitting completely. While they recognize the value of virtual fitting and the new technology of simulation, they do not think it sufficiently mature to provide precise fits to replace sample fitting to fix the patterns. They have recommended appropriate feedback for better visual representation. This study is limited to VTO, which is a part of the virtual fitting.

C. VIRTUAL TRY-ON AND CONSUMER BEHAVIOR

Many researchers have studied customers' attitudes about virtual fitting features online. Thus far, studies have been confined to analysis of a psychological model, and rather less attention has been paid to the effects of VTO on actual sales results. One study tested the theoretical TAM (technology acceptance model) [31] and found links among body satisfaction, the VTO experience, attitude toward the product, and online purchasing intention. The findings were as follows. Women with higher body satisfaction tended to perceive more enjoyment with the VTO feature. Body satisfaction was not related to the perceived usefulness of the virtual fitting. Both hedonic and utilitarian aspects of virtual fitting play a role in determining purchase intention [32]. Another study investigated the stimulus-organism-response psychological model. It studied the effects of viewing a virtual version of one's own body (or ideal body) and body satisfaction on a woman's concern for garment fit/size and attitude to use VTO. The findings are as follows. Women who were exposed to a virtual version of their own body measurements showed greater concerns about garment fit and size than those who were exposed to an ideal model. It was also found that women who have (1) greater concerns about garment fit and size and (2) lower body satisfaction are more likely to adopt VTO [12].

Another study emphasized the hedonic value of image interactivity of a virtual fitting room and its effects on online approach responses. It evaluated the effects of image interactivity (limited to the mix-and-match feature) and found that it acted as a stimulating experience and predicted emotional arousal and pleasure to lead, willingness to purchase, and willingness to patronize the online store. It means that the use of the mix-and-match feature for information and for fun is a key to involving emotion and can result in a positive attitude in online responses [33]. In addition, other studies have examined VTO as a marketing feature of mobile shopping and the value of mobile shopping and its rapid growth. They attempted to illustrate qualitative analyses of mobile shopping in terms of convenience and experience aspects. These studies have explained the main drivers of consumer behavior in a mobile shopping scenario and illustrated the hedonic and utilitarian value from the use of new features including virtual fitting [13].

However, even though many studies have reported on VTO technology and its value, very few studies have reported its effects on actual sales and fundamental meanings of consumer behavior. Therefore, the purpose of this study is to understand and interpret the qualitative meanings related to the consumer experience with VTO and measure its effects on actual sales. We define virtual fitting as limited to customers' try-on at the value chain of 'retailer/sales,' which is not virtual fitting during the design process. Our research was performed using the VTO features of L brand, a women's apparel brand.

III. CREATING VIRTUAL 3D GENERIC BODY MODEL AND 3D GARMENT DIGITIZATION

The process of 3D general body modeling, cloth simulation, and customized body modeling is organized as follows (see Figure 2). First, in '1) 3D model creation (human body modeling)', we created a virtual 3D model by digitizing the human body. We analyzed over 1,000 body measurements from our database through 10 line JavaScript code. Here, 34∼54 sizes are divided into 11 different sizes through grading. In addition, the 3D model can be created with 5 somatotypes

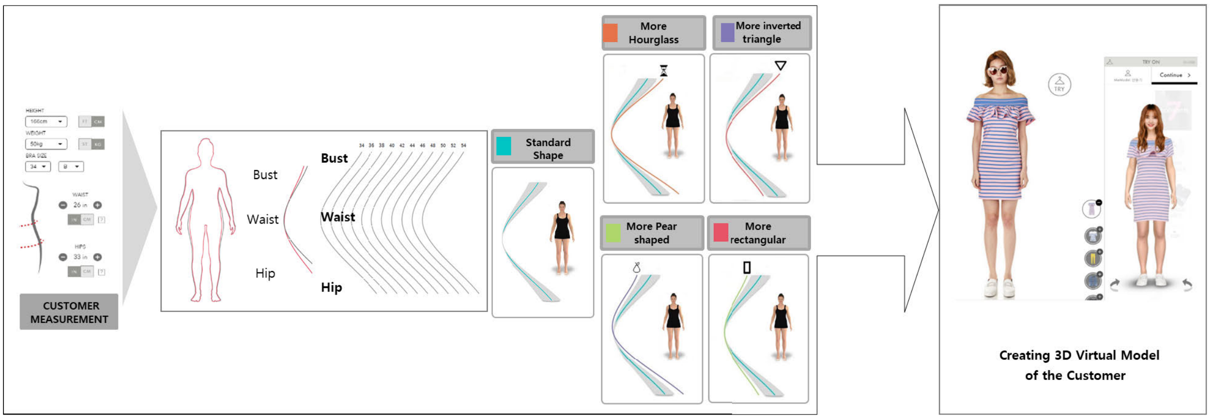

FIGURE 3. **Process of creating the 3D model with 5 body shapes and 11 sizes.**

including the standard body shape and 4 different body shapes (see Figure 3). The somatotypes include five types, including 4 different body shapes and 1 standard body shape. Second, '2) Garment photography' is a picture of a garment dressed on a mannequin. It is shot using an automated mannequin handling system. Since the clothes are photographed in mannequins, the impression of clothes in real human body can be displayed. Shooting time is 5-9 minutes per PCS (clothes), saving effort and time compared to shooting (fitting) a real model offline. It also does not require a professional photographer. Therefore, cost-saving effect is expected.

Third, in '3) Digitization (creation of clothed 3D model)', we completed a clothed model through the digitization and rendering of the garment. That is, we performed the work of cutting out the photographed clothes image and rendering it to the 3D model. These cut outs make the photographed clothes look more realistic by improving the ability of the rendering on the model. These cut outs drive our ability to render 3D models. The virtual 3D modeling and the cloth simulation of this study are a collaborative project with M company, a London-based tech startup that enables VTO online. Finally, in '4) QC (quality control) and realistic effect representation (6 motions)', we check out 3D visuals from multiple body shapes and every angle. And here, a model of six angles was completed. That is, it is used to create models of outfitted images from various angles and to rotate them in try-on. The try-on and the mix-and-match services are a part of the online mall feature at L brand, a women's casual brand.

A. GENERIC BODY MODELING–5 SOMATOTYPES FOR 11 SIZES

To make the VTO fun and interactive, our case study focuses on creating an attractive body model, realistic cloth simulation, and diverse poses to display the outfit well. We considered four major issues. (1) How can we create a customized model with the best quality as we transform the generic body model into an individualized body based on a customer's body measurements? How can we reflect varied body shapes and body sizes to cater to all customers? (2) What features make our virtual model more attractive? How can we generate a realistic body and skin tone? (3) When we simulate a garment, can we illustrate the size and fit accurately to help the customer? Can we express the fabric's physical properties well and express the drape and wrinkles so that a customer can feel the texture of the clothes? (4) How can we provide interactive and realistic simulation when a customer tries-on a garment? What features make our simulation more fun and more interactive? Focusing on these four issues, we created 3D generic models with diverse body shapes and sizes to embrace various customers' bodies. We then modified a generic model to an individualized body to reflect different body characteristics based on the customer's measurements.

The first step in virtual female body modeling was to create a generic female body model from the standard body size measurements. We used more than 1,000 points of body measurements from our database. Size classification, or size grading, was then conducted mainly on the basis of height (stature) and waist circumference (girth). The sizes category is divided into 11 sizes from 34 to 54. Basically, the 11 sizes are identically described as the standard body shape using linear grading. That is, new dataset of body shape is created using linear grading as well as the relevant part's size based on individuals' body sizes in order to generate more similar models with each consumer. The data of 11 sizes was created with the analysis by using machine learning based on the M company's accumulated data. The second step was to build four more body shapes for each size category because the standard body type is not applicable to all customers. Our data reported that only 22% of our 1.6 million customers could use standard body measurements, so we created four additional body shapes to cater to all other varied body shapes. When we defined additional body shapes, we used many specific sets of measurements from the data cluster analysis, and these body characteristics differed significantly from the standard shape. The body shapes are classified as 'more pear-shaped,' 'more hourglass,' 'more rectangular,' and 'more inverted triangle' [34]. In this study, we generated five groups of body shapes based on

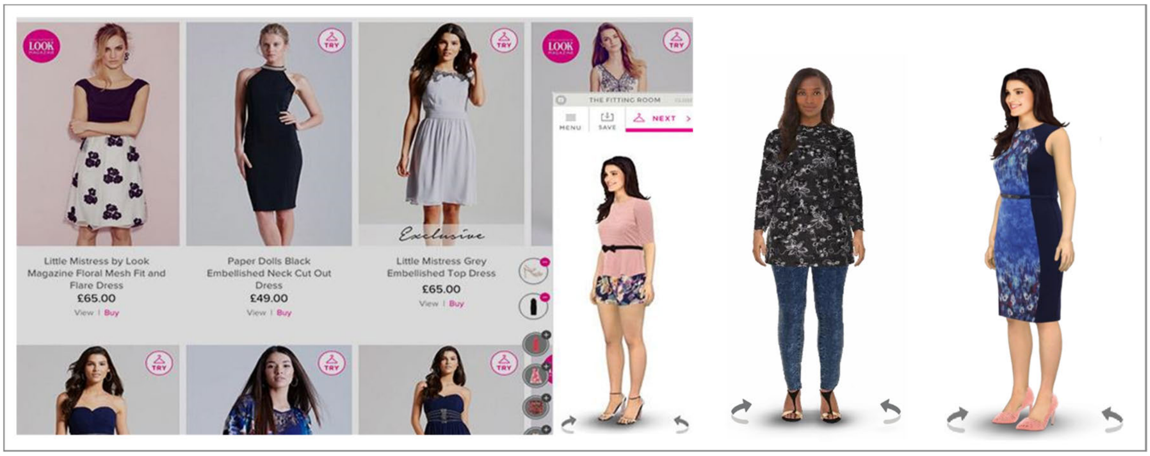

FIGURE 4. 3D virtual models.

the customers' profile, and we defined the 'standard body shape' as having similar proportions of the circumference of the bust-waist-hip and defined the other four somatotypes as follows. As noted, our data indicated that 22% of our 1.6 million customers have a standard body shape, 45% are more pear-shaped, 21% have a more hourglass shape, 10% have a more rectangular shape, and only 2% have a more inverted triangle shape.

1) Standard body shape—The bust and hips are basically the same size and similarly proportioned on the circumference of the bust-waist-hip.
2) More hourglass (rounded)—The bust and hips are larger than the standard body shape, and the waist is well defined.
3) More pear-shaped (triangular)—The hips are large, and the bust is narrow. The hips are fuller than those of the hourglass body silhouette, and the bust is narrower than that of the hourglass silhouette.
4) More rectangular (straight)—The bust and hips are narrower or wider than those of the standard body shape.
5) More inverted triangle—The bust is large, and the hips are narrow. The bust is fuller than that of the hourglass body silhouette, and the hip is narrower than that of the hourglass silhouette.

The third step was to make our female model more attractive and realistic using the techniques of animated pose, color expression, and realistic skin texture. We built various hair styles, facial tones/expressions, and stylish underwear for the virtual model. We tried to represent realistic skin to bring in vividness and built a variety of poses. We tried to present live skin and build six other poses at every 60° angle rotating view for being realistic. Figure 3 shows the creation of a 3D model that reflects 11 body sizes and 5 body shapes based on consumer measurements. That is, when a consumer enters his/her measurements, 3D virtual try-on uses the consumer's size and body shape type to create a 3D virtual model. The body shape types included the different body shapes in addition to the standard body shape. The images of standard body shape and different body shapes are listed from the left side, and the standard body shape of green body curve is also shown on each different body shape image to distinguish different body shapes by body shape. In other words, an individual's body shape is generated among five body shape groups based on the individual's own body sizes, based on which, 3D model including every angle is developed. Figure 4 shows 3D virtual models with different facial tones/expressions, hair styles, poses, etc.

B. GARMENT DIGITIZATION AND CLOTHED BODY MODELING

Clothed body modeling is used to create a 3D clothed body model by rendering a 3D garment mesh surface on the body. We propose a new method, instead of 2D CAD patterns, we used 3D garment photos; to make a 3D garment mesh surface because 2D CAD patterns are always copyrighted and require professional CAD software, therefore our study propose an efficient way. This process begins with 2D garment photographs taken with an automated photo studio system. The photographs of garments on mannequins were taken with customized equipment. Since the clothes are photographed in mannequins, the impression of clothes in real human body can be displayed. Our system does not require a professional photographer, and because one coordinator is wearing a mannequin costume, it takes only 5 to 9 minutes to photograph a single piece of clothes, and up to 200 photos can be taken each day. It thus saves time and money compared to conventional photographing methods.

From the 2D garment photographs, the first step is to remove the background and extract the garment boundary using image processing techniques such as edge detection and extraction of feature points. To find a feature point to build a garment silhouette, each pixel in each column/row is examined to find the first and last background color for each column/row. The garment region is then extracted. Among

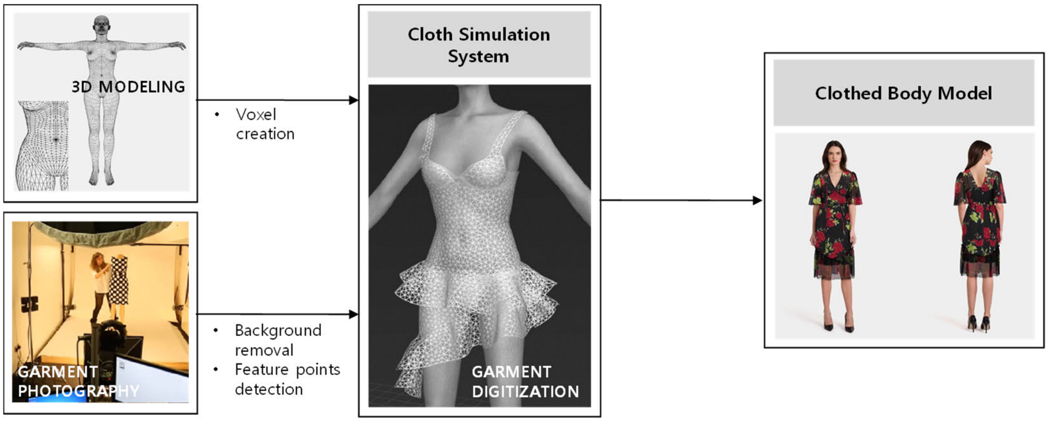

FIGURE 5. Digitalization of clothing and clothed body modeling.

the candidate feature points outlined here, we used an algorithm that selects a feature point of high curvature using a predefined feature point mask. We used a supervised learning algorithm (scaled conjugate gradient) and extended it with new options [35], [36].

The second step is to reconstruct the garment surface inside the garment silhouette. To make its surface smooth and balanced, we use an algorithm to insert the interior nodes uniformly inside the garment silhouette. Delaunay triangulation is applied to produce structured triangles by connecting points to form a convex polygon. In addition, some new nodes are inserted, and some overlapping nodes are eliminated to make the initial garment surface smooth, and Delaunay triangulation is again applied to distribute those nodes evenly. This process is iterated, and triangles whose edge is outside the garment region are removed for a good finish.

After the garment surface is created, a voxel-like process is applied to render the planar garment surface mesh onto the virtual body. The garment's triangulated surface is then placed near the virtual body, where feature points are used. Between the body and the 3D garment, an efficient collision detection/response algorithm is used to move the 3D garment around the body model. We then sewed eight pieces of surface views at every 45 degrees with a feature matching method and used an algorithm to minimize the stitching seam to create a seamless texture. The processing time for 3D garment digitization of each item from the garment mesh is less than 1 second. Figure 5 represents the digitalization of clothing and the process of clothed body modeling.

IV. CASE STUDY

A. CUSTOMIZED BODY MODEL AND VIRTUAL TRY-ON

Our VTO study was conducted with the online mall and mobile application of L brand, a women's wear brand. The most important thing is that the customer enters only five measurements, but our customized model reflects the individual's body shape and looks attractive with the target garments. To create attractive individualized models, we provided 25 models with various hairstyles and facial expressions (see Figure 2 and Figure 3). We also focused on accurate size and fitting with speed. The process for this VTO included four major steps. When a customer enters the main page, she selects the 'try' icon on the left corner of each fashion style image. The fashion styles are categorized by brand, type, size, and color to allow the customer to filter favorable items. The construction of an individual model then begins. The customer enters five body measurements: height, weight, bra size, body shape, and leg length category. If she wishes a more elaborate body shape, she can enter three more body measurements: waist girth, hip girth, and inner leg length (i.e., from the crotch to the inner ankle bone). She then chooses her own model from among 25 faces and hairstyles. With the customer's measurements, the generic model is first modified into a customized model.

The customer can now view a virtual adorned model and rotate it to six viewing angles. Our service recommends the right garment size and a fit guide, which includes tighter, comfortable, and looser around the waist and hips. A customer also can select other items to mix and match and search for coordinated items. Finally, the customer can share a photograph of the outfit model via SNS and obtain feedback and opinions from others. This provides the customer with a new retail experience.

B. QUALITATIVE INTERVIEWS ABOUT VIRTUAL TRY-ON

Our VTO service was carried out online in the mobile shopping mall of L brand from June 1 to August 13, 2017. A total of 105 SKUs of 2017 S/S styles were presented, and 8058 customers used the VTO service. We conducted a telephone interview with consumers who used the service to get feedback on the virtual try-on. In addition, we collected feedback about the service on our website and blog. In the telephone interview, we encouraged the consumers to talk freely about their experience and feedback about purchasing clothes using virtual try-on. It took about 15 minutes per person for an interview. We recorded the interviews and later transcribed them. Then the significant phenomena within the data extracted from the interviews were conceptualized and coded to categorize similar or related experience. In addition, we web-crawled the reviews on using virtual try-on through the website and blog to use them in the analysis. We used open coding to analyze the transcripts. Open coding is the initial step of theoretical analysis that pertains to the initial discovery of categories and their properties [37], [38].

During the open coding, each coder examined the interview responses and the comments line by line to identify codes within the textual data that could explain customers' experience. The coder then discussed each concept identified and named it after arriving at a consensus. We grouped these concepts into broader categories that reflected commonalities among the codes. Thus, we used open coding to delineate concepts and group them into meaningful categories. To validate the data coding results, three other researchers reviewed the interview details and keyword classifications.

We derived concepts from the open coding of the qualitative approach about consumers' virtual try-on experience of this study. As a result, we extracted six main concepts: confidence in apparel fit/style, model self-congruity, convenience, model styles, pleasure, and purchase intention. The result of the analysis showed that respondents mentioned the most about 'confidence in apparel fit/style (32.2%).' Due to not being able to see the suitability on online mall it raises concerns for consumers; however, virtual try-on in this study recommends size that fits well with 3D models similar to consumers satisfying their concerns. The actual responses include "The apparel will fit right, and the size recommendation service is nice," "I am pleased with the look of the right length pants/skirt." In addition, they said they wanted more detailed description about body size required in developing 3D model for virtual try-on.

Next, they mentioned a lot about 'convenience'. Consumers were bothered with having to change clothes several times when buying clothes. However, they mentioned that virtual try-on was convenient because they did not have to wear clothes. In addition, the use of a virtual try-on system was found to be convenient. The actual answers include "It's convenient because I don't have to wear clothes many times," "It's easy to dress the 3D model. In addition, 'model self-congruity', 'model styles', 'pleasure', and 'purchase intention' were mentioned a lot in this order. With regard to 'model self-congruity', thinking a 3D model created by the virtual try-on as themselves, they wanted to make the model more similar or better than themselves. With regard to 'model styles', the contents related to quality or styling of the 3D model were mentioned, and with respect to pleasure, the use of virtual try-ons was found to be interesting. They also said they wanted to change some parts to become more similar with them in developing 3D model. That is, they can choose clothes that fit better if 3D model is developed based not only on body size but also on the face shape and hair style. Specifically, while they were satisfied with the current 3D model, they wanted the face shape similar to them and realistic simulation as if they tried on real clothes. Finally, with regard to 'purchase intention', it means that consumers are willing to purchase clothes through virtual try-on. The actual answers include "The next time I buy clothes," "I will use virtual try-on to buy clothes" etc.

TABLE 1. Coding results: customer responses.

No	Customer response	Comment examples
1	Confidence in apparel fit/style	The apparel will fit right, and the size recommendation service is nice. I am pleased to look at the right length of pants/skirt. I want a more detailed description about the size/fit.
2	Model self-congruity	The model I used to try-on clothes is consistent with how I see myself. The model looks like me, but if I could change the avatar, I would like to change its proportion for a better look.
3	Convenience	The try-on service is easy to dress the 3D model. It is convenient because I do not have to wear clothes many times.
4	Model styles	I am satisfied, but I want to view an avatar with my face. I hope it provides the realistic simulation of cloth.
5	Pleasure	It is fun and awesome
6	Purchase intentions	The next time I buy clothes, I will use virtual try-on to buy clothes.

C. EFFECTS OF VIRTUAL TRY-ON ON ACTUAL SALES RESULTS

We analyzed the effects of VTO on actual sales results. To measure the effects, we collected customer data and sales data from June 1, 2017 to August 13, 2017. We then cleaned the data and filtered the return and exchange sales data to extract net sales and consolidated the data into one file of customer net sales data. We analyzed 11,029 transactions, and 8,058 customers used the VTO service. Primarily, we attempted to validate the effects of VTO in the dimensions of time and money and compared the sales results of VTO users and VTO non-users. We measured several indices as follows.

Our analysis illustrates that VTO has positive effects on visitor numbers, time spent, money spent, and sales amounts as follows (see Table 3).

It is found that visitor numbers, time spent, money spent, and sales amounts increased through VTO in this study. This indicates that consumers revisit the site because they are satisfied with the virtual try-on service as mentioned in the previous studies that state if consumers are satisfied with a service, they revisit the site that provides the service [39], [40]. The previous studies [41], [42] also view longer stay on online or offline malls as a positive phenomenon. This means that not only are consumers satisfied with the virtual try-on service, but also they are interested in making 3D model similar with them, so they use the service while staying longer on the site. Also, it can be interpreted

TABLE 2. Indices to estimate effects of VTO.

Measures	Definition	Formula
Visitor growth rate	Growth rate between the average annual visitors and visitors during the VTO service	[(visitor count VTO – average annual visitor count) / average annual visitor count] * 100
Revisit growth rate	Growth rate from the average annual revisit consumer count to consumer count during the VTO service	[(Revisit count VTO – average annual revisit count) / average annual revisit count] * 100
Time spent online	Amount of time a customer spent online at every visit	Time spent
Time spent online growth rate	Growth rate from the average annual amount of time spent to amount of time during the VTO service	[(Time spent VTO – average time spent) / average time spent] * 100
Virtual try-on participation rate	Ratio of the number of visitors and try-on users	(VTO user count / total visitor count) * 100
Purchase conversion rate	Rate of conversion, total resulting number of sales from the number of entities, business that potentially attracts purchase	(VTO items purchase count / items purchase count) * 100
Average number of purchases per customer	A count of items a customer purchases at one shopping visit	User : (VTO purchase item count / VTO user count)
		Nonuser : (VTO nonuser purchase item count / VTO nonuser count)
Average sales per customer	Amount of purchase per a customer	User : (VTO purchase amount / VTO user count)
		Nonuser : (VTO nonuser purchase amount / VTO nonuser count)
Return rate	the rate of return counts from the sales counts	Return count during VTO / Total sales count during VTO

that they buy clothes easier by actually dressing a 3D model with a body that is similar to their body and giving them the same effect as wearing real clothes. The most key finding is the remarkable 27% decrease in the return rate, which resonated with other researchers' opinions. In online malls, consumers cannot actually try on and buy clothes, so the return rate is relatively high because they purchase clothes without actually checking their fit. However, the VTO in this study allows consumers to dress a 3D model with the most similar body to their body through a total of 5 somatotypes including 1 standard body shape and 4 different body shapes as well as 11 sizes and buy clothes, significantly reducing the return rate. That is, returns due to the wrong size/fit seem to be decreased with VTO.

TABLE 3. Analysis results.

Division	Results
Visitor numbers	The revisit rate is increased by 2.24 times after the use of the VTO (growth rate of 324%).
Time spent	The time stayed online site with the VTO service is increased by 2.37 time (growth rate of 337%).
Money spent	The average sales per customer is increased by ₩14,000 ($13) after the use of the VTO.
Sales amount	The purchase conversion rate is increased by 2.8 times after the use of the VTO. The return rate is decreased by 27% after the use of the VTO.

V. CONCLUSION

This study has three key findings through developing virtual try-on and examining effects of the VTO on sales results. First, in this study, we created a virtual 3D model reflecting the more detailed size and type is generated based on the customer measurement, thus making it more realistic and natural looking. Second, customers responded positively to this service. The most significant finding is that the return rate decreased by 27% through the service. We used the consolidated customer net sales data from Lucky Chouette, a line of women's casual wear from Kolon FnC, from June 1 to August 13, 2017. A total of 105 SKUs of 2017 S/S styles were examined, and 8,058 customers used the VTO service. During this 2.5 month period, 11,029 transactions took place.

Third, our observations of customer responses indicated that they were satisfied with the VTO service with various values. The marketing and e-commerce literature consider customer value to be an important predictor of customer behavior and decision-making [43], [44]. Customer value has been used as a theoretical foundation in explaining customers' decisions in making purchases [45]. In virtual try-on of this study, when consumers enter their basic body size, a 3D model similar to the consumer is automatically generated, allowing them to dress the model with clothes they wish to purchase. This belongs to a functional value among customer value types. Through the VTO, customers could check the size and fit of apparel well, especially pants and skirts. For convenience, filtering the wrong size/fit could reduce customer returns, and it was proven to result in a 27% reduction. In terms of hedonic value, consumers feel that it is fun to create a 3D model similar to them and dress it, which makes them stay longer at the site. Also, the results show that the average sales per customer increased by 14,000 won, or $13. To sum up, VTO could provide convenience, enjoyment, and a new experience that has a positive effect on purchasing; we conclude that it could boost purchase intention and sales in the near future. The most important contribution of VTO is to replace physical fitting rooms and help retailers reduce their return rates.

One limitation of this study is that only 8,058 customers used VTO over a period of 2.5 months. In addition, we could not analyze the mass customer responses. Therefore, if more customers' responses are used over a longer period of time for more items, the results will reflect more general opinions and elicit better insights with pros and cons about this service. However, this study has several implications for researchers and practitioners. First, this study contributes to our understanding of the entire relationship of VTO, actual sales, and customer experience and estimates the actual sales effects via data mining. Second, this study contributes to IS research by using customer data to study the effects of a virtual try-on service on sales results. The previous research lacked examining effects of a virtual try-on on the sales with customers' actual data. Third, in this research, the VTO service customers were interviewed based on the qualitative research as a way to extract the concepts for using the VTO service. These extracted concepts were then applied to the customer value theory to interpret and explain customers' experience. This study also has practical implications for using the VTO services. As the interest in the virtual try-on service increases, many fashion companies try the service. This study can provide guidelines for companies that expand their business to the online commerce and companies that plan and operate the virtual try-on service. Due to the tendency of reluctance to face-to-face contact due to COVID-19 along with the development of information technology, the online commerce activities of untact services are boosted. According to this tendency and the consumption trend, this study not only enhances the convenience and satisfaction level of consumers but also contributes to profit increase of online retailers.

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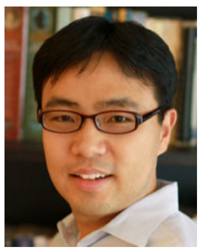

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