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Research Article

A Case Study Analysis of Clothing Shopping Mall for Customer Design Participation Service and Development of Customer Editing User Interface

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Following the development of networking and mobile devices, the technology of managing the offline information online is being conducted widely. Also, as the social services have become much more active, users are registering and managing their personal information on online websites and sharing it with other users to acquire the information they need. For modern people living in a smart city, the planning of smarter services is required. The convergence of ET and IT or advanced scientific technologies such as AI or Big Data is often mentioned whenever the smart city is discussed. Nevertheless, smart services that could introduce smart solutions to conventional industries or change existing lifestyles should also be considered. Therefore, this paper discusses a service related to the convergence of the traditional clothing industry with IT and a service wherein CT is converged with systems that allow customers to participate in the design work and share the designs they have created. In other words, this study is a case study of CT and IT services in the clothing industry and is inclusive of an apparel shopping mall service that encourages customer participation in design, a customer-oriented editing user interface, and a copyright management system. The results show that both production method and production capacity largely affect the user interface of apparel platform services, with customer freedom significantly correlated with their functional roles. Moreover, the lead index is shown to be one of the factors restraining customer freedom. With this analysis, an apparel shopping mall wherein customers participate in the design work has been developed especially for clothes with more complex designs. The shopping mall emphasizes functionality from the perspective of customer use. At the same time, an online environment for an apparel service appropriate for the smart city has been implemented.

1. Introduction

Following the development of networking and mobile devices, the technology of managing the offline information online is being conducted widely. Also, as the social services have become much more active, users are registering and managing their personal information on online websites and sharing it with other users to acquire the information they need. Recently, the application whose intelligent agent recognizes a user's habits or a lifestyle and provides proper information is increasingly appearing in the online market. For example, a service that provides the information about the places the user often goes or the available means of transportation to user's destination is provided currently.

This is achieved by searching suitable information from the accumulated data pertaining to the user's history of visiting particular places. People nowadays pay more attention to their appearances especially when it concerns clothes, wearing different clothes depending on with whom they will be meeting or avoiding not to wear the same clothes the next day. Currently, a method which conveniently acquires the data on user's clothing habits and provides useful information to him/her based on the accumulated data is not available. Thus, to discuss a service where the existing

clothing industry, IT-converged services, and CT are integrated to allow customers to participate in the design process and share their designs with others, an application which recommends a suitable design to the designer by accumulating the history of clothing choices of these customers to grasp a particular customer's clothing habits or inclination has been proposed. All of these tasks can be performed and managed with a smart device.

Technical development has accelerated the change of social structure and contemporary lifestyles [1]. Technical advances are transforming us from a postmodern to a participating generation [2]. The normalization of technology and the reduction of computer equipment cost focus on an efficient creation method between developers and users, who tend to focus on the recent small-quantity batch production [3]. Such customization is also being attempted in costumes. Current clothing items for customizing do not create diversity.

Historically, designers used to deliver a one-sided message that has changed in contemporary times, however. This is caused by the democratic desire of customers who have led the way in changing traditional business models [4]. Nonetheless, it is doubtful whether there are participation and creativity of a design for the current clothing design items in customer-participating services. Despite the good customer-participating structure, there is a lack of professional leadership for the service. In 2012, Armstrong and Stojmirovic argued [2] that the point of inducing customer participation is that it must be easy, fun, and less burdensome in terms of price, and it must give excitement to produce creative works under the leadership of an expert. Note, however, that the current t-shirt customizing is insufficient to produce passionate creativity as customers exercise their creativity to the full extent. Such is partly due to the lack of Back End technology. Thus, Design U developed a DTP printing image extracting system that restores the image from the model where the customer designed before. Technically, it prepares a presumption of customer design participation for various clothing items. From the customers' point of view, it is necessary to study the development of a user interface that can be edited in a more complicated content format and a contents format that can communicate with customers. If the designer designs a creative clothing item and suggests lead content, source contents need to be designed for customers to edit. This part can be made by uploading a customer-created image or sharing through the purchase of fee-paid copyright. The design source is sharing content wherein customers can easily and joyfully complete designs. Content sharing with a small amount of copyright is a method created by Richard Stallman who supported the copyright opposition movement and created a concept of free distribution of information. Lessig [5] also supports the flexible copyright method that reuses content information since it directly affects the participating culture.

This study first analyzed the customer editing screen user interface cases for customer design participation in the clothing shopping mall, investigated the pattern copyright cases used for customer editing, and finally developed a customer-participating editing user interface application for more complicated clothing items.

2. Related Research

Examining the clothing product development process is an essential part in preparing and supplying quality products to a promising market in a timely manner at a reasonable price. The common steps involved in designing clothing products are research, design development, and production [6]. The design development step starts with design sketching and sample production, and most of those who are participating in this process use computer-aided design (CAD) for efficiency and accuracy (Figure 1). The existing CAD systems are often effective in downstream production wherein grading, and marker planning processes take place continuously. Owing to a series of research works carried out by modern engineers and designers, Virtual Sampling, which allows a 2D pattern to be applied to a 3D human model to evaluate its wearability and appearance, has become a standard procedure when designing clothing products [7–10].

Cloth simulations are usually performed to assess the effect of geometrical variation or physical aspects. In most cases, the former draws faster results without considering the physical properties of the cloth being used. This makes it difficult to reproduce the dynamics of the clothes [12]. The latter allows more realistic simulation in understanding the dynamics and provides better accuracy as the cloth material's structural properties will be considered for the simulation. In other words, both the law of dynamics and the law of mechanics are based on discrete dynamics, fluid dynamics, or elasticity theories, all of which determine the cloth behavior and its interaction with external environments [13, 14]. Various methods often categorized as either a continuous physics-based or a discrete physics-based approach have been studied and proposed till now, emphasizing realism or computational efficiency [15]. The former introduces a rigorous, strict representation of a cloth in accordance with the continuum mechanics often adopting either a finite element (FE) or a finite difference model to produce a solution [16–18].

Meanwhile, by using the continuous Lagrange equations to represent the displacements from equilibrium positions, Terozopoulos et al. [16] modeled a surface deformation of a cloth, whereas Eischen et al. [19] employed the nonlinear shell theory and Li and Volkov [20] depicted the image of a cloth immersed in a quasistationary viscous fluid in terms of fluid dynamics. For this, a nonlinear FE method was applied to derive the system equations. This method aimed to produce various types of physical models for computer animation, which are effective in generating the behaviors instead of modeling a certain deformable cloth with high degree of accuracy. This method allowed the qualitative reproduction of similar behaviors without requiring a large number of computations [21]. The instability and high expense are major problems for the continuous physics-based methods, whereas the discrete physics-based methods represent cloth as a grid of particles interacting with each

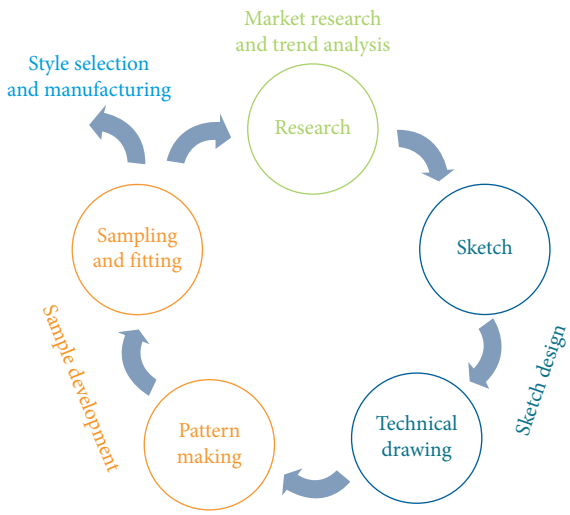

Figure 1: Fashion product development cycle [11].

other as well as with the external world following either the force-based Newtonian dynamic laws [22, 23] or the Lagrangian dynamic laws or the energy minimization criteria, all of which are energy-based approaches [21]. Characteristics such as low complexity and simple implementation are the underlying reason for the popularity of the mass-spring system that is also known as the particle system) [15, 24–27]. Nonetheless, an important issue remaining for this system is its accuracy as the physics of a cloth deformation is based on the approximation that is often represented by the mesh topology with a certain discrete physics-based method that influences cloth simulation. A number of meshing and remeshing methods were proposed in the past including Lienhardt [28], Praun and Hoppe [29], and Attene and Falcidieno [30]. Various forms of mesh topologies have been studied by Lu et al. [31], who then validated and proposed an optimal pipeline that is quite adequate for the preparation of the mass-spring model in a scanned garment reconstruction. Meanwhile, some other researchers turned their attention to pattern designing or making. An interesting interactive coevolutionary CAD system for the parametric pattern design was introduced by Chen et al. [32] who produced garment patterns using a neural network along with an immune algorithm.

A fuzzy logic-based optimization of garment pattern design was achieved by Chen et al. [32], whereas Lu et al. [31] proposed an expert knowledge-based approach that is helpful to customized pattern designing. Guo et al. [33] contributed to providing a detailed review of AI applications in the fashion industry. The previous studies suggest that sketch design is still an unexplored field of cloth design and development. Although the use of commercial CAD software such as Adobe Illustrator™ or CorelDraw™ has become a common practice in the sketching process, and their efficiency and effectiveness have been proven, the original idea of a designer starts by creating some sketches, consuming much time and effort. The survey conducted among Hong Kong fashion designers clearly showed that they are continually looking for a user-friendly design support system to reduce their working hours when designing new clothing [34]. As one of the methods to achieve this, several companies established their own special digital fashion library like SnapFashun™ from which designers can borrow their desired elements to create new designs.

There was a unique development when Mok et al. [35] introduced a customer-oriented design system that allows general customers to create their sketches, adopting some evolutionary computational techniques. Further notable work came from Wan et al. [36] who claimed to have used some shape deformation techniques to create realistic sketches based on standard technical sketches. Fashion illustration and technical sketches are the two main pillars of the design industry (Figure 2). Specifically, fashion illustrations focus on drawing the products that the seller wishes to show and sell to the customers by showing how the products can be arranged and what their uniqueness is. This system translates the technical sketches into fashion sketches without omitting any details. By fitting the same clothing to a different fashion figure that can assume several different positions, the customers could understand the concept and may find the products attractive [11, 37–42].

3. Customized DTP Clothing: Case Analysis

Customized DTP clothing service is drawing much attention, and solutions for copyright issues were analyzed in this study using actual cases. Subjects of the analysis include service methods, user interfaces for the user-edited screens, and pictures used for printing. Among the DTP being serviced, five cases with clear distinctions have been selected for the analysis in order of introduction: My T, Snap T, Design U, Printing Factory, and Adidas. Among these, My T, Snap T, and Printing Factory are mainly selling T-shirts, so they can be regarded as products that originated from IT companies or printing factories instead of being clothing brands. Design U is a service provided by contemporary Korean traditional clothing brand TS, and Adidas is originally one of the clothing brands. In this aspect, the T-shirt business is often run by nonclothing brand firms, and the requirement or level of difficulty of production pertaining to the design of their clothes is quite low. Their interests lie in the files that they need to print. If a DTP service has to be provided for complexly designed clothes like women's clothing, the level of production difficulty will be high, and higher understanding of their design is required.

The DTP mentioned in the case analysis refers to digital textile printing, a method which replaces the conventional dyeing method and saves the time required for cutting patterns so that this method is quite suitable for the modern customized services. The user interface allows convenient communications with the system the user wish to select, aiming to reach the level of communication the customer desires.

Also, from the perspective of recently developing information communication and design technologies, the user interface is an interactive space for the various types of computer-based equipment. Operating the surrounding products in our everyday lives is a normal phenomenon in

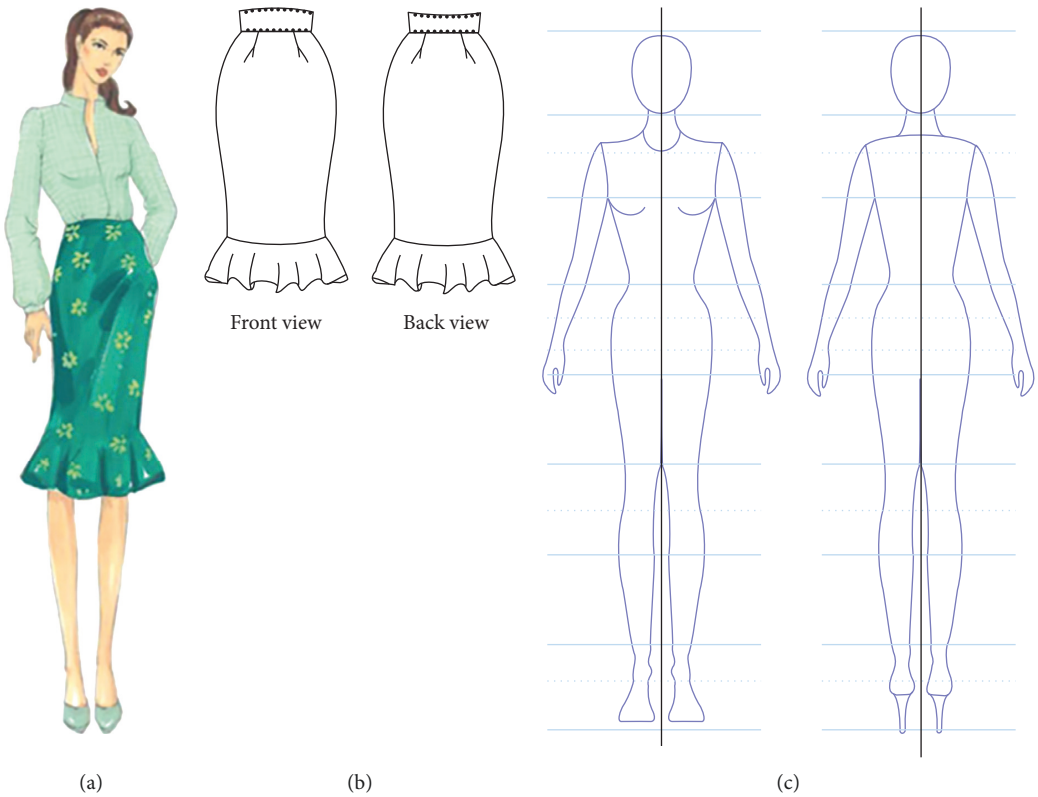

Figure 2: Illustration of fashion illustration, technical sketch, and croquis. (a) Fashion illustrations. (b) Technical sketches (flats). (c) Croquis (human figure template).

the environment created between products and user. For instance, the user just needs to use the hardware or the software of the vehicle he/she owns through the embedded user interface even if he/she does not know how it works or what is the principle of it.

A good user interface design makes it easier for the people to operate the products they encounter in their everyday environment. The design includes not only arranging the composition of a computer/similar device's screen or the elements of hardware operation in a convenient way but also includes all the designs of the things the user experiences with the products.

Moreover, since the people who will be providing such service should have a high degree of understanding of the design and form, the work is much different from simply concentrating on the printing files. Although there are many more services utilizing DTP printing, these five services have been selected because they offer customer-participating editing screens (Figures 3–8).

My T (Figure 3) is an app that helps produce personalized T-shirts. It provides an internal service platform that introduces the printable pictures created by artists from various fields and receives a royalty (T-mileage) once they have been sold. The printing house can be arranged, and the optimal printing method will be automatically provided. This service targets consumers who look for T-shirts that are highly individualized but affordable. The customer editing screen is arranged as follows:

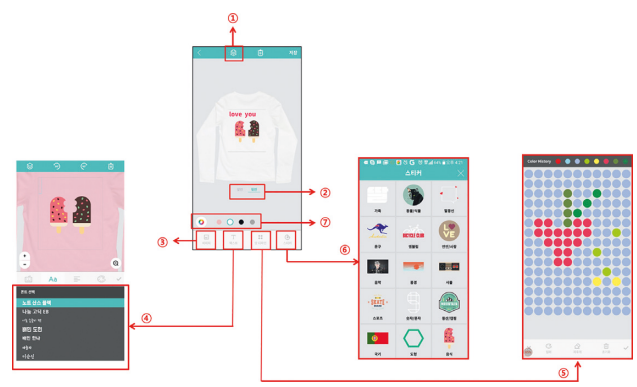

Figure 3: My T [11]. ① Layer control. ② Area selection. ③ Import image. ④ Text editing. ⑤ Dart editing. ⑥ Load Sticker. ⑦ Select background color.

(i) Button ①: *Layer adjustment*. Distinguishes the pictures to be placed in the foreground or background when several pictures overlap.

(ii) Button ②: *Area selection*. This service can be used for only two areas (front or back), selecting the designated rectangle domains. This shows that the clothing will be produced prior to printing.

(iii) Button ③: *Image import*. This function usually imports images (jpg, without transparent area) from the customer's mobile phone.

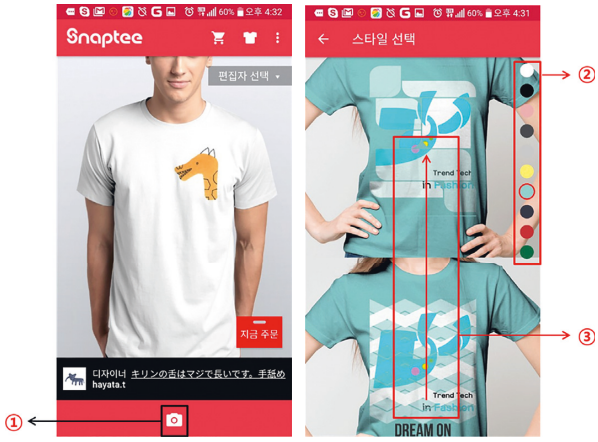

Figure 4: Snap T [38]. ① Upload image. ② Select background color. ③ Go down and see various examples.

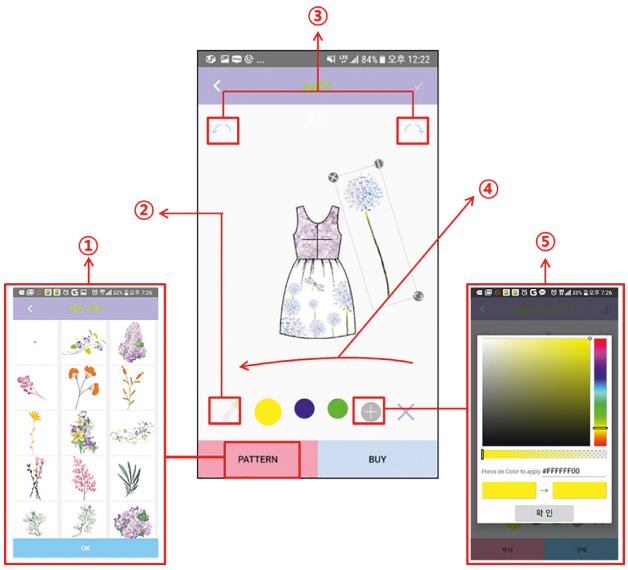

Figure 5: Design U [39]. ① Import image. ② Eyedropper. ③ Revert/revive. ④ Swipe: front, back. ⑤ Color selection.

(iv) Button ④: *Text button*. Font selection options will be displayed once clicked.

(v) Button ⑤: *Dart editing button*. Once the button is clicked, the screen on which the dart can be edited will appear.

The size can be adjusted, and certain figure or letter(s) can be imprinted by coloring each dart. In this area, some game factors can be reflected as well.

(vi) Button ⑥: *The sticker is imported*. Sticker refers to any of the artworks provided by various artists, and it is mainly a PNG file with a transparent domain. Images and stickers have apparently been distinguished in this service based on the source of the image (i.e., user's mobile phone, the platform itself, etc.) or file format (i.e., transparent or nontransparent).

Figure 6: Printing Factory [40]. ① Revert/revive. ② Area selection. ③ Simulation view (2D). ④ Start work. ⑤ Text editing. ⑥ Select background color. ⑦ Image selection. ⑧ Image editing.

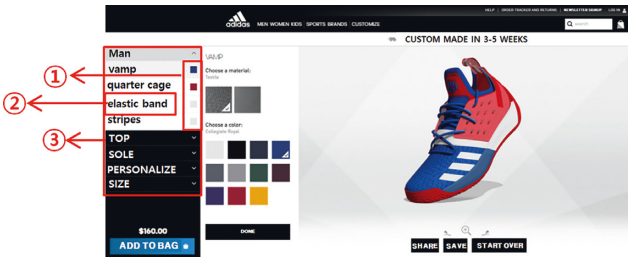

Figure 7: My Adidas [41]. ① Color selection. ② Material selection. ③ Area selection.

(vii) Button ⑦: *Background color selection*. Each T-shirt has its own fixed background color. In the case above, however, the color selection option is quite limited as there are only four background colors.

Meanwhile, Snap T (Figure 4) is a service initiated by one of the Hong Kong companies, aiming to reflect collective amusement to Instagram or T-shirt design. Its editing screen has been a little more simplified, but the social function has mainly been strengthened. With this service, the customer can disclose or present his/her design; if another customer purchases the design, a 10% sales royalty will be collected. The editing screen is straightforward as shown in Figure 4: one's image is uploaded by clicking Button ①; for the uploaded image, various types of draft designs will be displayed when the customer drags the mobile phone screen downward. This is made possible by marking the image with different geometric shapes and inserting varied transparency levels in advance, giving a dream-like design effect. The background can be selected with Button ②; since it will be printed on the preproduced T-shirt, only the existing colors can be selected.

Design U (Figure 5) is an app developed to load clothing contents more intricate than T-shirts, aiming for better communications between the designers preparing a certain designer brand and customers. At the time of development, designers of contemporary Korean traditional clothing had loaded these dress items reflecting modern trends. This service adopts the "print first, produce later" method. Around 100 arbitrary images matching the items have been

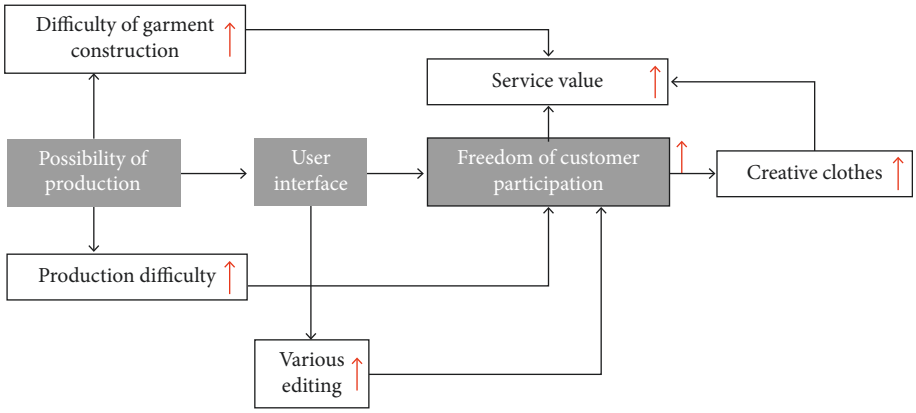

Figure 8: Factors affecting the user interface.

uploaded to the app. The customer needs to download the desired design or pattern to import it when editing. The customer editing screen is shown in Figure 5. ① is the image import button with which the customer can apply the downloaded image. ② shows the eyedropper function that elaborately leads the customer when he/she chooses a color. It could be difficult for the customer to find a sensible color in a short period of time among the colors suggested in ⑤. Nevertheless, the customer can have the desired color by importing the image file that includes the same color from the pattern samples and eye-dropping in the desired area. This function can be used to pick out a subtle color shade from a beautiful pattern. There are three circles on the right side of button ⑤ acting as a palette. The customer can start designing by preparing three color combinations in advance with an eyedropper or a color selection function. When the eyedropper in ② has been activated, the palette changes to the color designated by the eyedropper; when this is inactivated, however, it is possible to paint the clothing with the desired color by putting one of the colors in the palette in any area. The function that reverts or restores the working content can be performed with ③. With ④, the front or back of the dress is displayed when the customer moves the screen to the left or right so that the back side can be painted after the front side by shifting the screen to the side.

Although this service provides only two selections (front and back), it is possible to apply the service to all the areas. In other words, the edited arbitrary pattern will be adjusted following the outline of the dress drawing by clicking the check button on the upper right side.

Despite its designing convenience and better looks (prettiness), this method consumes much time since the images have to be put on the clothing sample one by one. In the picture, even though the pattern seems to be pieced together between the different domains, it is little challenging to make the image a perfectly joined and extended one because these domains are actually those of different pieces of fabrics. Therefore, it will be helpful if the work can be performed separately (subdivide) for each domain.

Printing Factory is a Korean T-shirt printing website who undertakes the editing/printing of costumes for fashion shows or K-pop idols by partnering with the relevant companies. On their website, they offer a customer-editable screen as shown in Figure 6. They are currently planning to extend their service to a DIY business wherein customers can make their clothes. Although their basic business strategy is to cooperate with as many clothing companies as possible continuously, their business is still limited to T-shirts and sportswear. ① is the button for undoing or restoring the performed work. ② selects the area to be designed. For T-shirts, four areas (i.e., front, back, right, and left sleeves) are usually available. In addition, each area is not defined by the rectangular box so that all areas of the cloth can be designed freely. ③ is used to check the simulation.

As the present screen, it is replayed in 2D mode; the difference is that the front (back) side of the front (back) sleeve will be shown just next to the front (back) face after the design has been completed so that the customer will be able to see how the T-shirt will look like after the sleeves have been attached. This is because the designed sleeve area is not recognized as just an ordinary arm part of the clothing but as an unfolded design (i.e., coloring the sleeve pattern). The merit of direct designing on a sleeve pattern is that the customer's design details can be reproduced without any data loss when printing them on a cloth. This offers many conveniences in the production process while reducing customer complaints. The customer may modify the design after seeing the simulation, but this process can be a little inconvenient as well. When the operation start button ④ is pressed, the three major functions such as Image, Text, and Color will appear. Button ⑤ is for text editing that supports font selection, contents input, sorting selection, color coating input, shadow code input, horizontal/vertical position adjustment, and blur effect.

The designing freedom of text itself has been enhanced. For the T-shirts, the text function has been improved as texts are often used more widely compared to women's or men's wear. Button ⑥ is for background color selection. The desired color can be selected from the RGB color scheme. Button ⑦ selects an image. The images are provided by theme, but one's images can be uploaded. Button ⑧ is used for editing the image by enlarging, reducing, and rotating it. The image setting window is provided separately for image cutting, image filter selection, or transparency adjustment.

Figure 7 shows My Adidas, a personalized shoe production service by Adidas. According to Adidas, they have commercialized this online service reflecting the trend among consumers who pursue their unique fashion and personality. This pertains to the highest level of Maslow's Hierarchy of Needs, so this personalized service is a prospective service targeting modern people who can feed and house themselves. When designing the Adidas shoes, the colors can be selected from the fixed set of colors and applied within the fixed areas. The materials can be selected from the given set of materials as well. When selecting an area, the Screen View rotates the shoe 360° degrees to show each area, whereas the applied colors can be viewed through 3D shoe design every time they have been applied. Adidas adopts many fixed functions, especially for the color selection. This is to help the customers match colors more professionally. Although customer freedom may be reduced, limiting customer choice by offering special color combinations would assist them better in terms of designing. The elements affecting user interface in the DTP customer-participating type clothing platform are shown in Figure 8. In the first place, production possibility is the base of the user interface. If possible items are different, the items and functions of the user interface vary. The user interface determined by such production possibility determines the degree of freedom of customer participation. If freedom of customer participation is high, more creative work can be produced. Production possibility, user interface, and customer's degree of freedom form the relation below. Firstly, if production possibility is high, complicated clothes have increased service value. If the production process using DTP is difficult, the customer's degree of freedom increases. In terms of user interface, if the diversity of screen function increases, the degree of freedom increases. If the customer's degree of freedom increases, the creativity of output increases together with the service value. In other words, if the customer's degree of freedom increases, production becomes complicated, and user interface needs a complicated function, but it increases service value. In contrast, the lead index restricts customer participation. It is intended to apply some restriction for professional and refined outputs by the customer with the help of professionals. It is expressed in the form of restriction of the customer selection area and fixing of the location. In the case analysis, ID has a high lead index. Customer participation and leading index apply mutual restriction. While the customer's degree of freedom is intended to restrict creative works, the lead index enables customers lacking creativity to express designs professionally by leading the method of restriction. Moreover, even if there is high freedom of customer participation, it does not have a positive effect on customer participation.

Customer participation may vary by generation based on the experience of Internet device. Generally, younger generations with high level of freedom have a positive reaction to customer participation. Therefore, it is ideal to keep a suitable level of service and price by maintaining the appropriate degree of freedom of customer participation concerning the market. There is a high level of freedom of customer participation and service, so it is important to create value for various customer groups. If easy clothing items are focused on, it creates severe competition within the item and decreases the value. Therefore, it is necessary to apply various clothing items to the DTP customer Half Design participation service. The complexity of cloth, diversity of customer participation, degree of freedom, and evaluation of user interface are listed in Figure 9. The diversity of user interface is related to customer participation's degree of freedom. Thus, the lead index is not evaluated in Figure 9. Likewise, 5 cases with clear differences including App and Web are analyzed for the evaluation of the index above to figure out the service situation in this industry. There are three analysis cases: App for My T (Korean), Snap T (China), and Design U. As for the web, Printing Factory and Adidas are analyzed.

4. Analysis Result

4.1. Result of Case Analysis for the DTP Clothing Service User Interface. The analysis table below is expected to be used as a reference to evaluate the platform function of DTP customizing clothing service editing screen and production method. In the evaluation items, factors affecting customer participation's degree of freedom are marked in bold. If the computer and mobile environments support customer editing screen in the development environment, the customer's degree of freedom is high. In the design areas, when it moves down, the degree of freedom is high, and the degree of freedom of Whole is highest. In analyzing the user interface editing and customer's degree of freedom, if there is no color restriction, the degree of freedom is high. The degree of freedom for Free Color is highest. In the selectable color, the degree of freedom is high if more than one color can be selected. If there is a spoilt, it has a high lead index. In the image, seven factors including Upload Customer's image, Provide image, zoom/Rotating image, Image repeat, Image game, and Text are considered. If there are many factors, it has a high degree of freedom. Next is a service on production complexity. It is related to service value, which includes the following. If the difficulty of Item goes down, the production complexity of clothing will increase. If Design Area moves down, the complexity of DTP editing will increase. If the number of pattern pieces for design increases, the production complexity in DTP printing editing increases. If there are many pattern pieces overall, production complexity will increase. Regarding the production method, preprinting and postproduction are closer to a traditional customizing production process than preproduction and postprinting. Compared with preproduction and postprinting, the difficulty of production is three times higher.

4.2. Result of Analyzing Creation-Sharing Contents Copyright Cases. Figure 10 shows a chart of the analysis result of the copyright management system with which the creations belonging to each brand can be shared. The shareable creations are divided mainly into art graphics that can be used for designing purposes and finished clothes. In the chart, the

DTP Clothing Half Design Online Platform				1. My T	2. Snap T	3. Design U	4. Printing Factory	5. Adidas
Environment			App/Web	App	App	App	Web	Web
			Computer				o	o
			Mobile	o	o	o		o
Difficulty of garment Construction	Item		T-Shirt, Eco Bag	o	o		o	
			Sports / Spandex					o
			Fashion Clothes			o		
	Design Area		Limited Area	o	o			o
			Free Area					
			Whole			o	o	
	Designable Pattern Quantity		1 sheet		o			
			Within 1/3 Quantity					
			Within 1/2 Quantity	o				
			All			o	o	o
	Whole Pattern Quantity			4	4	7~12	4~6	4
Editing function	Back ground Color	Color Select	No selection					
			Choose from provided colors	o	o			o
			Free Color			o	o	
			Color Spuit			o		
		Selectable degrees of freedom	Choose only one color	o	o			
			Choice of 1, or more colors			o	o	o
	Image		**Upload Customer's image**	o	o	o	o	x
			Provide Image	o	x	o	o	x
			Zoom, Rotating image	o	x	o	o	x
			Image Effect	o	o	x	x	x
			Image repeat	x	x	x	x	x
			Image Game	o	x	x	x	x
			Text	o	x	o	o	x
Production method			Production –> Printing	o	o			o
			Printing ->Production			o	o	

Figure 9: Case analysis of DTP clothing half design platform.

five brands and an additional brand, Real Fabric (Korean fabric printing web service), are included. This service has a robust copyright management system. Even though My T claims to be paying regular returns to the artists when using their designs (pictures), the process is not explicitly shown on their service screen. Meanwhile, Snap T offers a simple editing function, but they have a relatively proper social role for sharing creations and returns. They publicize the clothes design results, and the profits are shared in case of any purchases made. They do not provide art graphics, so the designers should upload their creations from their own devices. In this aspect, it is an art graphic sharing service. Real Fabric has a selection box showing the art graphics presented by the expert artists and which can be applied to

Copyright management		1. My T	2. Snap T	3. Design U	4. Printing Factory	5. Adidas	6. Real Fabric
Revenue share system	Graphic Design	○	○				○
	Clothing Design		○				
Copyright Flows			○				○
Revenue share automation			○				

Figure 10: Analysis of copyright management system by brand.

the fabric, sharing the profit with the artist. The profit-sharing follows their reimbursement rules. Since the copyright holders can be checked in the services provided by Snap T and Real Fabric, their services can be said to offer a better environment wherein the graphic artists can openly create artworks and socialize with their coartists and customers.

5. Development Concept Map

5.1. Development of DTP Clothing Service User Interface Web (Excluding Knitwear). Figure 11 shows the designer-participating customer user interface development DB UML for the application of various clothing items. It mainly consists of customer information, image upload information, other information related to image editing, and color information.

5.2. Creative Work Copyright Application Planning for DTP Half Design Platform. Figure 12 is a plan for the method of uploading works to use in the platform. If customer A uploads work, customer B buys the work at a minimum copyright fee and saves it to his/her own web file in the platform. While the internal contents of the web file can be applicable to half design participation, the original copy cannot be downloaded. As the method of paid pattern application by customer B in the design participation, when a customer performs design, there is an open image column on the editing screen. Here, free or fee-paid creative works appear in an image for selection. If the desired works are selected, it can be reused for the customer's work immediately by editing. Such method is quite reasonable as the copyright holder is explicitly specified and payments are made safely when the designs are downloaded to the customer folder.

6. Development Result

6.1. Result of Development of Customer Editing User Interface Applicable to Various Clothes. Currently, the case studies show that customized/personalized DTP clothing services are limited to T-shirts and sportswear. Although Design U once attempted to do women's wear lines, much time was required to reproduce the clothing sample after reflecting the customer design information since the area distinctions were not made clear, but the method used by Printing Factory increases the customer participation level by providing the list of areas for each clothing piece. Note, however, that they use one view for each clothing area. This method does not

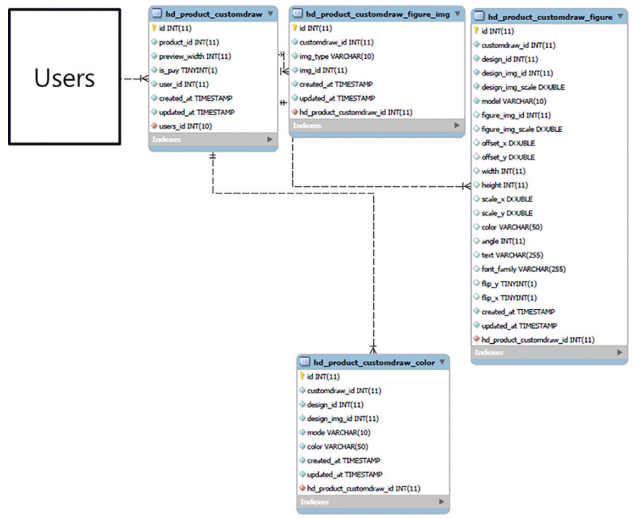

Figure 11: User interface web of UML of DTP clothing service.

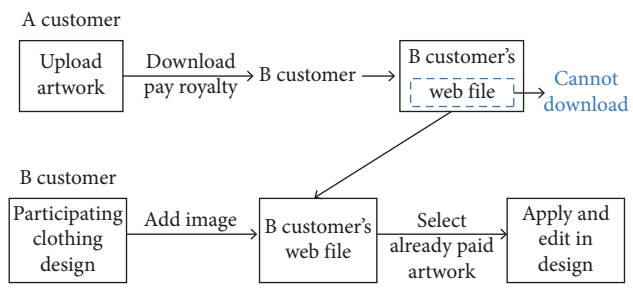

Figure 12: Copyrighted artwork in half design platform.

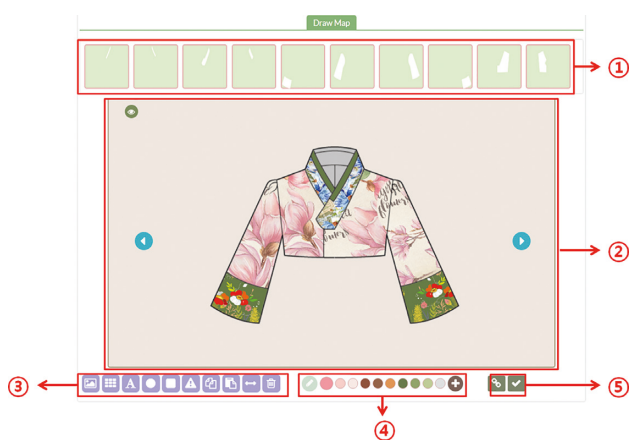

Figure 13: Customer design participation screen of design user interface.

allow the customer to see the overall effect, so they added the simulation view function separately. Considering this, for more complicatedly designed clothing, the Design U's method which connects all the areas in a single view would be more suitable. Therefore, for the customer view, this method has been adopted as in ② of Figure 13. ① in Figure 14 is an Area, Selection List. When an arbitrary area has been selected, the area becomes semitransparent

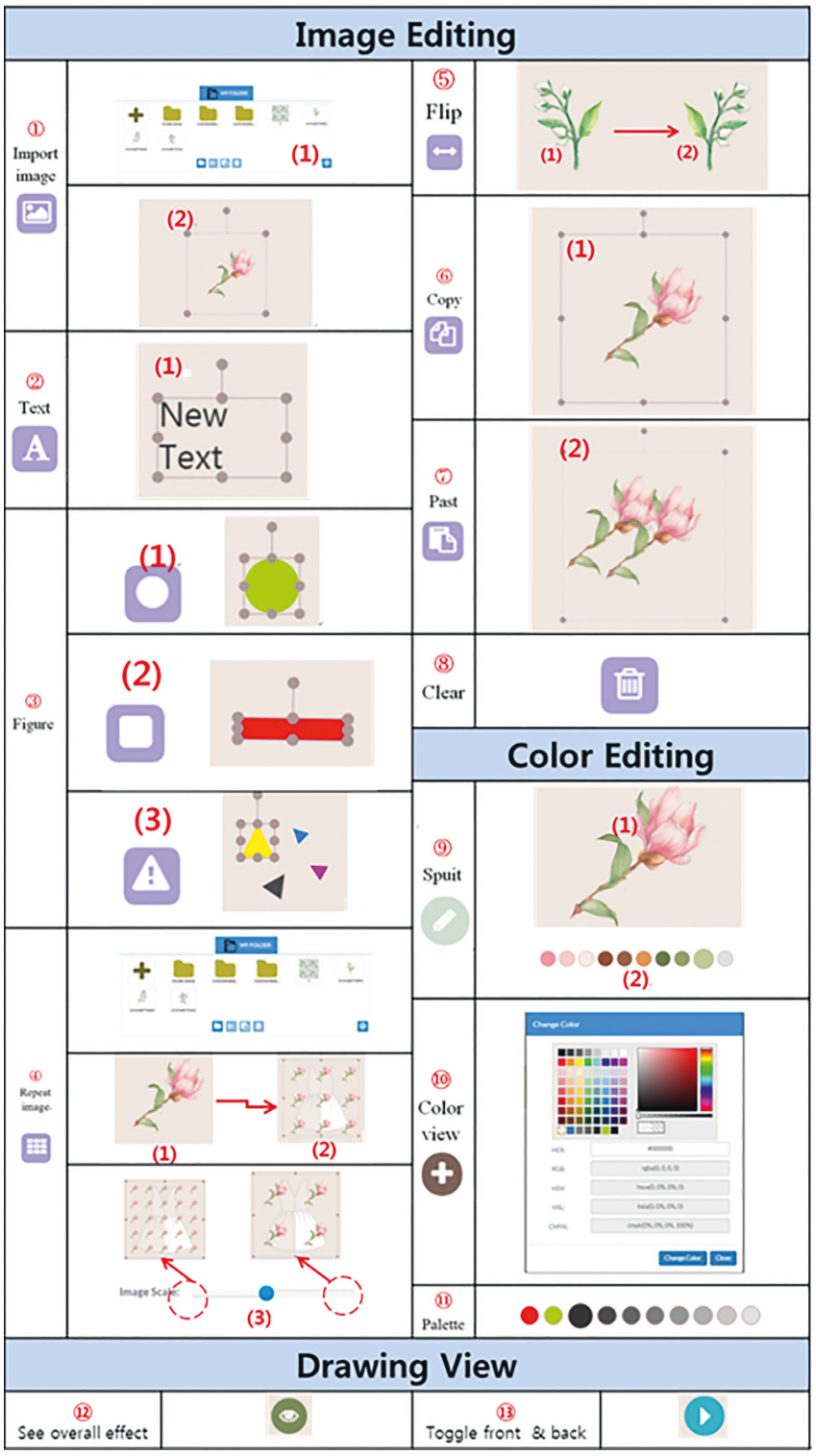

Figure 14: Editing function.

(Figure 14) so that the customer can recognize where the selected area is in the picture. When an area has been selected, the entire work output stays in that area. As a result, by pressing the eye-shaped button on the upper left after completing all the areas, the screen will show the result as in Figure 13. In other words, all the images designed in each area will be masked to show them neatly so that the customer can easily image his/her finished work. This method is being applied to complicated wear with many selection options with which the customer can select each area from the complexly set up areas and represent the designs on a single screen.

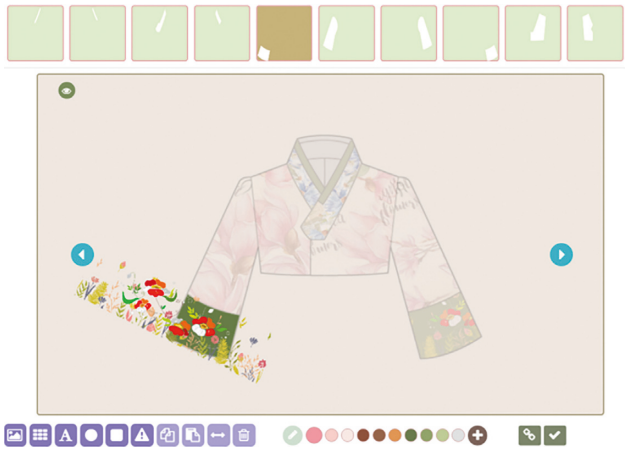

Figure 15: Customer design participation screen of design user interface.

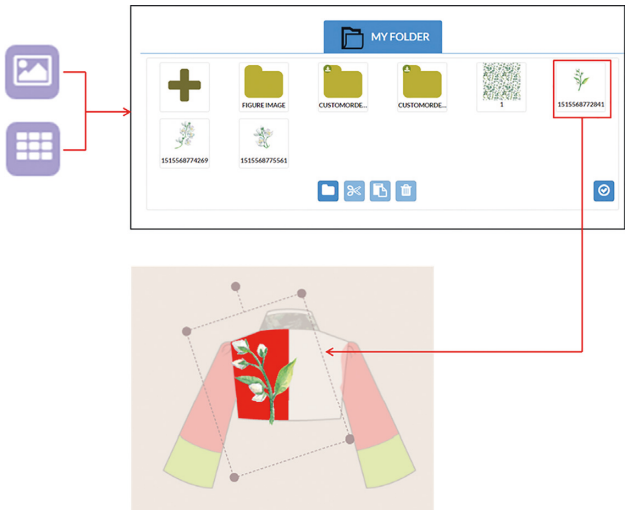

Figure 16: Development screen.

The customer design participation screen of the design user interface is divided into five (Figure 13): ① selection area, ② drawing area, ③ image editing, ④ color editing, and ⑤ save. It is divided into selection, coloring, image editing, color editing, and finally saving. Also Figure 15 shows customer design participation screen of design user interface.

As shown in Figure 14, the customer editing screen consists of ① Area Selection List, ② Drawing Area, ③ Image Editing Button, ④ Color Editing Button, and ⑤ Storing and Sharing Buttons. The details of each button are summarized in Figure 14. Button ① is an image import button. Once the button is pressed, the screen shifts to the customer folder where the paid or free pictures have been downloaded. The desired picture can be selected here. (1) of ① allows the user to import the files from his/her mobile phone or PC. (2) of ① shows the picture selected from the folder that has been generated on the screen. (3) is an editing tool generated for each design element, performing five functions such as selection, enlargement, reduction, rotation, and shift. The editing tool automatically appears when a single item is selected from the elements such as text, geometric pattern, and pattern repetition. Thus, the pattern selected in (1) can be freely edited with editing tool (3) and displayed in (2) by designating the desired location or size.

② is a text button used to input text by clicking the button and positioning it anywhere on the screen. The editing tool is automatically generated when the text has been entered as an element, performing a function similar to image editing. (1) of ② shows the fonts. After the text is selected, one of the available fonts will be selected to decorate the text. ③ shows patterns from which the simplest ones such as (1) circle, (2) rectangle, and (3) triangle were selected. The pattern can be represented freely by drawing it as one big shape or several small ones. By clicking the desired color, the pattern color can be changed. ④ is an image repeating button, and its image import method is the same as ①; after importing an image, however, an arbitrary square should be drawn together with the click-drag function. By doing so, the image selected from (1) repeatedly appears in the square as in

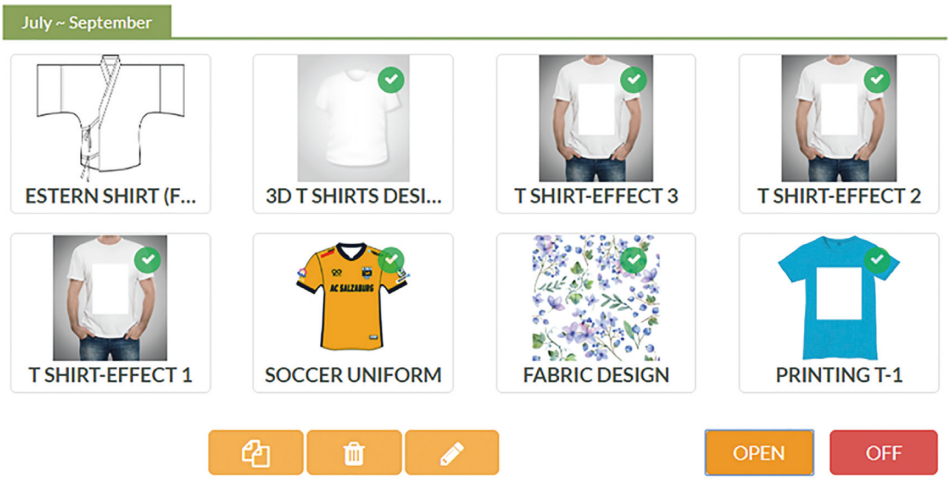

Figure 17: The service/product management screens on which the products to be tested are being uploaded.

Example: My T	
Features	1. Service Area: 2 2. Service Area Form: Square 3. Clothing Background Color: Assignable
Simulation Graphic	Picture of item laid flat
My T	
Representation on the platform	 Before application / Adaptation process / After application

Figure 18: The result obtained from restricting an image within the square.

(2). If one wishes to adjust the size, it will become more substantial when the scale button is moved to the right side. The editing tool is also automatically generated for the finished pattern element so that the direction of pattern repetition can be adjusted by the rotation function of the tool. ⑤ is the flip function allowing only horizontal reversal. In other words, when flip has been performed by clicking one of the elements (e.g., image, repeating image, or text), (1) will disappear and (2) will appear.

⑥ and ⑦ are the copy and paste buttons, respectively. By clicking the ⑥ copy button after clicking the image (1) of ⑥, button ⑦ will be activated. The copied image will be pasted when this button is pressed (image (2) of ⑦).

It is possible to develop the copy function without the attach button; in such case, however, there could be some difficulties when one attempts copying in different areas separately. For this reason, both buttons have been developed as separate ones. ⑧ is a Clear button with which the

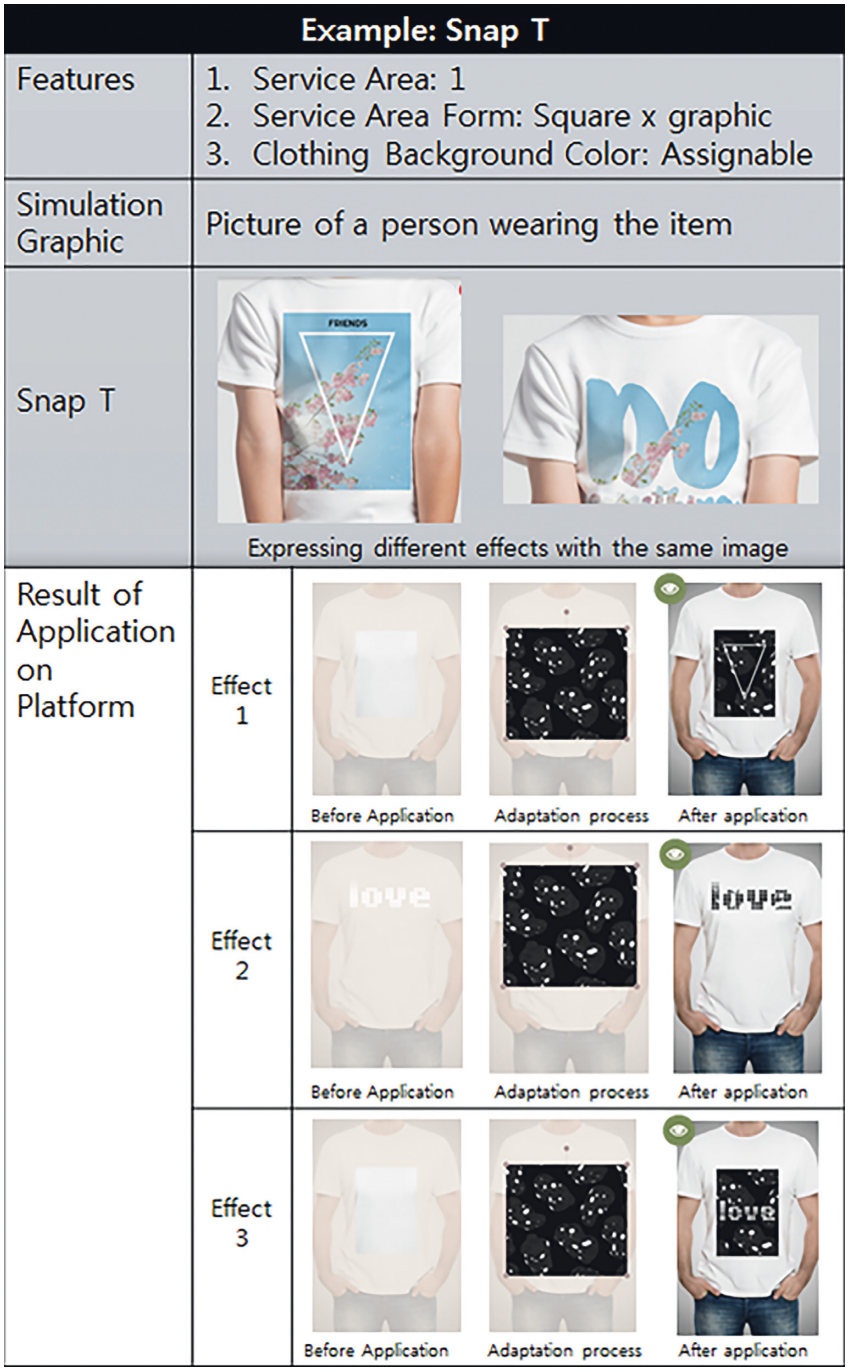

Figure 19: The results obtained when the effects have been brought into the restricted area.

design element selected arbitrarily can be deleted. ⑨ is an eyedropper. With this button, the arbitrary elements and all the colors in the image can be put into the palette ⑪. For instance, when one wishes to use a color combination consisting of Pink, Burgundy, and Green for image (1) of ⑨, one needs to activate the eyedropper; after clicking the palette, click the color to be applied on the pattern. Then, as shown by (2), the colors are classified on the palette so that a natural arrangement of colors will be created. In addition, if one wishes to use the color collected with the eyedropper for the background, one needs to click the eyedropper button again to deactivate the eyedropper. ⑩ is the color view with which one can freely select new colors or input a color code in the HEX box to get the desired color. ⑪ is the palette. There are a total of ten palettes, and the color can be changed in each palette. Customers can have a user-friendly palette by clicking each palette and entering the colors they often use or prefer. ⑫ performs the See Overall Effect. When this button is clicked, the screen in Figure 13 where each area has been selected in advance will be changed into the screen in Figure 15, showing the image applied with all the patterns and colors.

Example: Design U App	
Features	1. Service Area: Entire Area 2. Service Area Form: 2D Form 3. Clothing Background Color: Free Choice
Simulation Graphic	Flat design with a black line (item)
Design U App	
Result of Application on Platform	Before Application  Adaptation Process  After Application 

Figure 20: The result obtained when it was possible to carry out the design in the entire area freely.

The customer editing screen consists of the Area Selection List, Drawing Area, Image Editing Button, Color Editing Button, and Store/Share Buttons.

6.2. Copyright Image-Applied Screen. In Figure 16, when clicking the image open and pattern buttons, a customer web folder appears. In the folder, images that customers want are gathered, but they are not available for download. The pattern is free or copyrighted. Moreover, in the copyrighted patter, it can apply the design to the customer web folder.

7. Test Evaluation

To test the efficiency of the platform developed, the methods used for the services have been applied to the platform to confirm their validity. As examples, the brands such as My T, Snap T, Design U, Real Fabric, and Ninetyplus have been selected as each of them has a distinctive individuality in their respective service function. All of their service approaches were implemented on the platform. Figure 17 shows the service/product management screens on which the products to be tested are being uploaded.

The main feature of My T is that the image is restricted within the squared area (Figure 18). Although such a service does not allow an elevated level of customer freedom, it offers a much more convenient and cost-saving production method, leading to a better marketability because of its direct effect on the customer preference in low-cost products. Through the test, it was verified that the method of defining

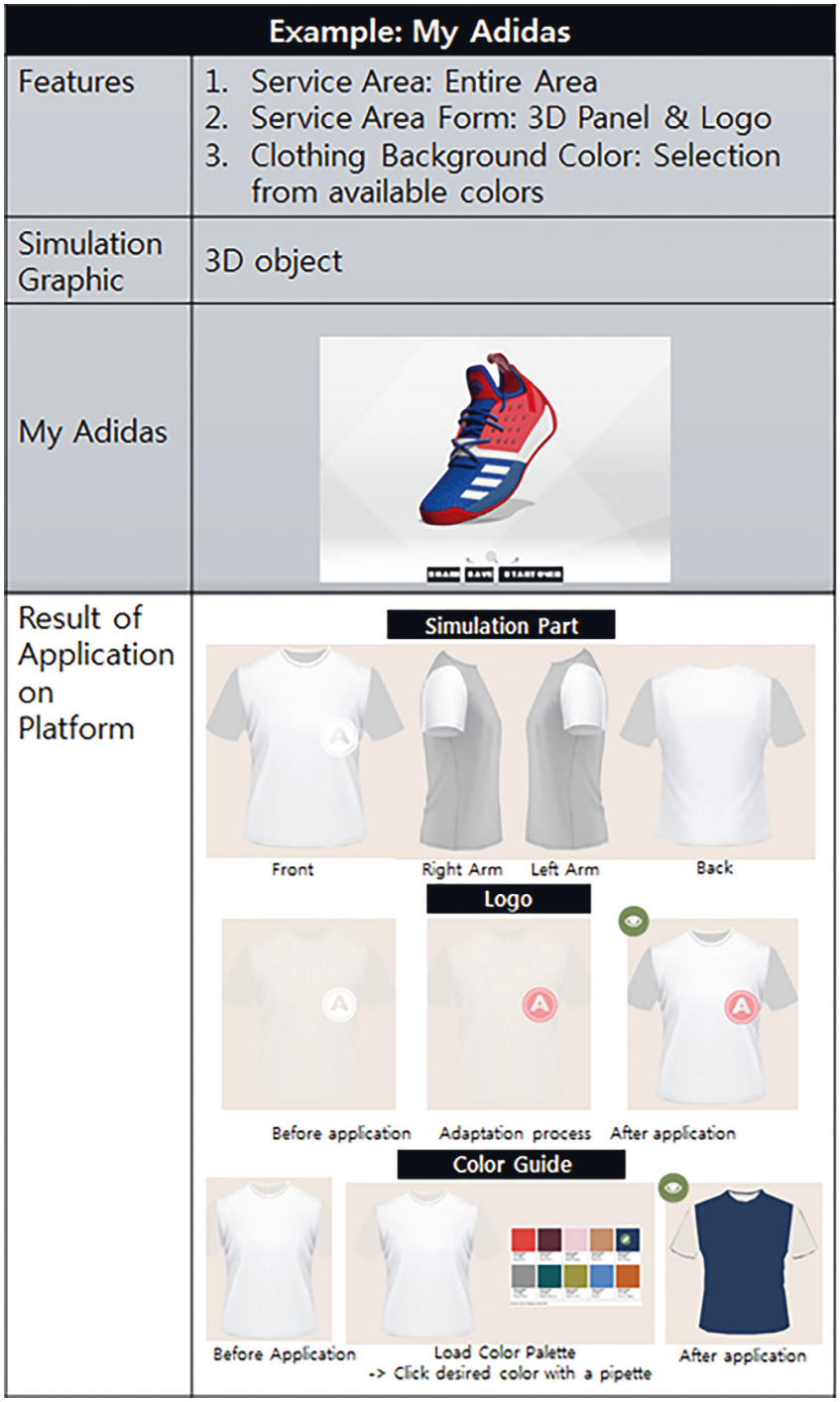

Figure 21: The result obtained when represented in 3D.

service area in a single/multiple squared areas is viable on the platform developed in this study.

Snap T shows various types of effects within the squared area (Figure 19). This is to allow customers to create an effect like a professional artist. Such an effect can be achieved with a png file which determines the transparency, color, and the shape of the area. Through above test, it was verified that the service which allows customers to create an artistic effect just by giving various types of effects on a single photo is viable on the platform developed.

The App version of Design U allows customers to design in every corner of the clothing (Figure 20). This is also a service method in the table presented in Figure 19, which embraces a high degree of customer freedom. Through the test, it was possible to verify that such a service approach is also viable on the platform developed.

The My Adidas product in Figure 21 was represented in 3D where customers cannot insert any images. However, it is possible to set the colors automatically for the logo or the geometric patterns in the system such that the customers

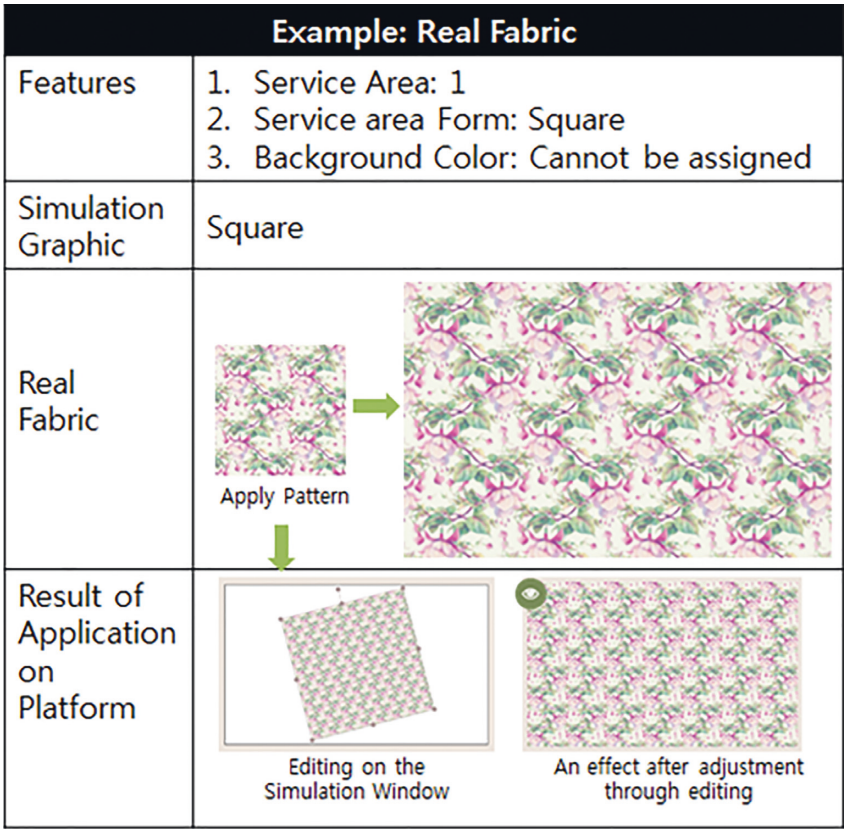

Figure 22: The result obtained from the application on a fabric.

without expert knowledge in designing can also achieve professional-like color matching by making selections from the colors or color combinations prepared by experts. To perform a similar service, a 3D image was used for a T-shirt while making it possible to select the logo color separately on the platform. Although color selection has not been completely limited, the customers will be able to select some professional color combinations based on the color reference given. That is, they can pick their desired colors with a pipette function from the color palette image while using the editing feature. The test result revealed that even though the 3D-based simulation did not produce detailed images, it was verified that such a service can be achieved on the platform.

Figure 22 shows the result obtained from the application on a fabric. The service by Real Fabric can only be applied to fabrics and its simulation screen has a square shape. The information related to the proportion of a pattern based on its length and width can be checked in advance and it is possible to make changes for a single-pattern element as many times as the customer wants as well as the adjust of sizes. The same fabric used for the Real Fabric's simulation was used on the platform for testing. As a result, it was not possible to change the length or the width of the fabric instantaneously such that this problem was solved by selecting a fabric with the desired length and width from the product list in advance. Also, editing was freely performed on the pattern by using the functions (i.e., Enlarge/Reduce, Shift, Rotate functions) having a "Pattern Element Refit" function. Also, compared to the Real Fabric service where only one pattern can be applied at a time, the proposed platform allows to add several patterns on top of another, making it a superior platform as a customizing service for fabrics.

Figure 23 shows the result obtained from performing a simulation on the existing customized service offering no simulation function. Finally, Ninetyplus (90+) is a company specializing in customized soccer uniforms. This company does not have any simulation systems and adopts an ordering system which requires a customer to download an Excel style order form from the company website and upload it after filling in the specifics. Then, they show the customer their draft design repeatedly for three times. Such a relatively complicated procedure has to be taken as they lack the simulation system. An uploading test was performed on the platform with product of this company by using the simulation technique and the result showed that all the problems can be solved at the same time. One major feature of the color guide used by Ninetyplus is that only a couple or triple of colors can be used. This is to prevent the customers from creating a rainbow-colored design by coloring every corner as they please. By contrast, the proposed platform allows all the predesignated areas will be painted with the same color simultaneously once a single arbitrary area has been painted. This validates that the service similar to one that is being offered by Ninetyplus (i.e., developing a design with just two or small color distribution) can also be achieved on the platform developed in this study.

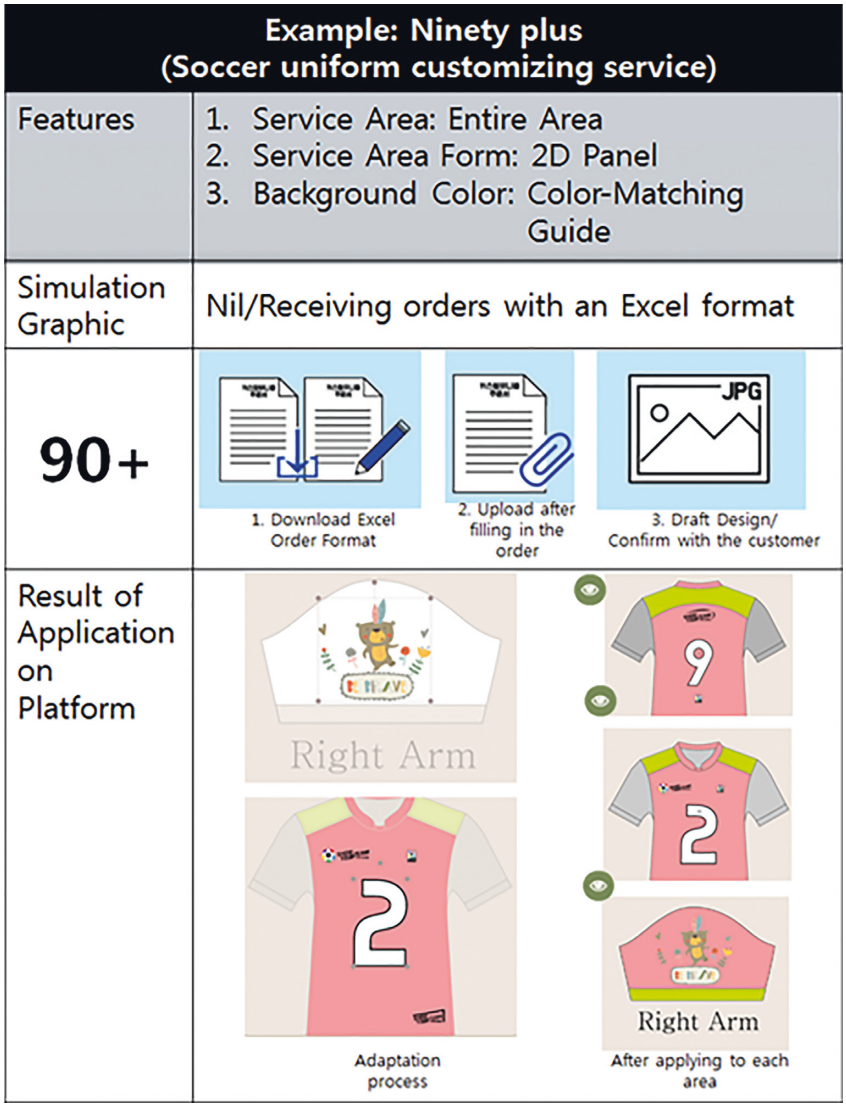

Figure 23: The result obtained from performing a simulation.

8. Conclusion

In this study, research was conducted on the instances of IT-integrated services in the clothing industry to develop an upgraded service version. The case analysis involved the user interface for customer editing and the management system including copyrights. Based on the research, a DTP half design service website with an integrated function to which various methods can be applied has been developed.

Thus, in this study, the DTP clothing half design service was developed. The existing DTP clothing half design service mainly focused on t-shirts. It is related to the production method, and the editing screen user interface by production method is associated with the degree of freedom of customer. In this study, with the premise that there is no DTP design participation service on trendy fashion items other than t-shirts, the user interface to express trendy fashion is developed. Based on Figure 7, trendy fashion includes inner fabric, which has a high level of difficulty in terms of the composition of cloth. The developed user interface also supports the overall design of pattern, free color, and various editing functions. Moreover, the current user interface enables designing t-shirts and fabric. The user interface covers the preprinting and postproduction method. With this development, digital printing is expected to be applied to women's clothing with various complexities as well as t-shirts so that customers can express their creativity and personality and it fills the gap with the market.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

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