Augmented Reality Fashion Apparel Simulation using a Magic Mirror

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Abstract

Digital technology innovations have led to significant changes in everyday life, made possible by the widespread use of computers and continuous developments in information technology (IT). Based on the utilization of systems applying 3D(three-dimensional) technology, as well as virtual and augmented reality techniques, IT has become the basis for a new fashion industry model, featuring consumer-centered service and production methods. Because of rising wages and production costs, the fashion industry's international market power has been significantly weakened in recent years. To overcome this situation, new markets must be established by building a new knowledge and technology-intensive fashion industry. Development of virtual clothing simulation software, which has played an important role in the fashion industry's IT-based digitalization, has led to continuous technological improvements for systems that can virtually adapt existing 2D(two-dimensional) design work to 3D design work. Such adaptions have greatly influenced the fashion industry by increasing profits. Both here and abroad, studies have been conducted to support the development of consumer-centered, high value-added clothing and fashion products by employing digital technology.

This study proposes a system that uses a depth camera to capture the figure of a user standing in front of a large display screen. The display can show fashion concepts and various outfits to the user, coordinated to his or her body. Thus, a "magic mirror" effect is produced. Magic mirror-based fashion apparel simulation can support total fashion coordination for accessories and outfits automatically, and does not require computer or fashion expertise. This system can provide convenience for users by assuming the role of a professional fashion coordinator giving an appearance presentation. It can also be widely used to support a customized method for clothes shopping.

***Keywords:** Magic mirror, Augmented reality, Digital clothing, Hairstyles, Fashion coordination*

1. Introduction

In the fashion industry, studies are being actively conducted to develop consumer-centered, high-value added fashion items, including MTM (made-to-measure) type clothes, using digital technology. This virtual clothing environment has been made possible by enhancements in cyberspace-related technology. Three-dimensional scanners and three-dimensional virtual clothing simulation programs have been developed, and such technology has been incorporated with IT, thus digitalizing the fashion industry. Fashion companies have continuously automated working processes to prevent productivity from decreasing, which has occurred owing to reductions in the labor force. Many companies have introduced automated systems to improve working efficiency and reduce costs in technical areas [1, 2]. The existing fashion industry depends on 2D images for garment design, and does not adequately consider the physical characteristics of

consumers. The development of virtual clothing simulation software, which has played an important role in the fashion industry's IT-based digitalization, has led to continuous technological improvements for systems that can virtually adapt 2D design work to 3D design work. Such adaptations have greatly influenced the fashion industry in general.

The textile and fashion industry utilizes computer-aided design/computer-aided manufacturing (CAD/CAM) as a technique for planning and designing clothing patterns. These systems are based on technology that can virtually copy actual textile and knit products, to reduce the number of processes required for producing textile and fashion items, and to plan accurate and varied products. i-Fashion developed a system to show, on a large display, the results of an avatar-fitting simulation program using a full CG of a user's body, formed with a 3D whole-body scan of the user. Microsoft presented a simple technology for overlaying 3D dresses over a user's image, which was captured with a Kinect input device. Virtual clothing simulation systems that employ 3D technology depend on materialization of accurate patterns to maintain superiority in the customized product development field. As the use of virtual clothing simulation systems has steadily increased, many online fashion shopping malls have been adopting them. In the past, virtual simulation systems could only simulate square pieces of cloth, such as flags. More recently, many virtual clothing simulation programs that exhibit improved accuracy, efficiency, and marketability have been developed [3-6].

This study proposes a magic mirror system that uses a depth camera to capture the figure of a user while they are standing in front of a large display. Using augmented reality technology, the display can show fashion concepts and various outfits to the user, coordinated to his or her body. When the coordination functions of the system are not activated, the display shows an unaltered image of the user, similar to a mirror. When a user approaches or touches the display, they will activate system's coordination system. The information expressed on the screen can immediately provide the fashion information users want. The proposed system will enhance user convenience and will be used as a customized clothes-shopping method in the near future.

2. Related Works

2.1 Augmented Reality

Virtual reality establishes real-world environments using computer technology, and enables interaction between people and computers by their involvement in the virtual world. Augmented reality, which was derived from virtual reality research, integrates invisible information created using a computer model with real-world information, to enable interaction. The goal of augmented reality is to allow users to realistically experience various types of digital content.
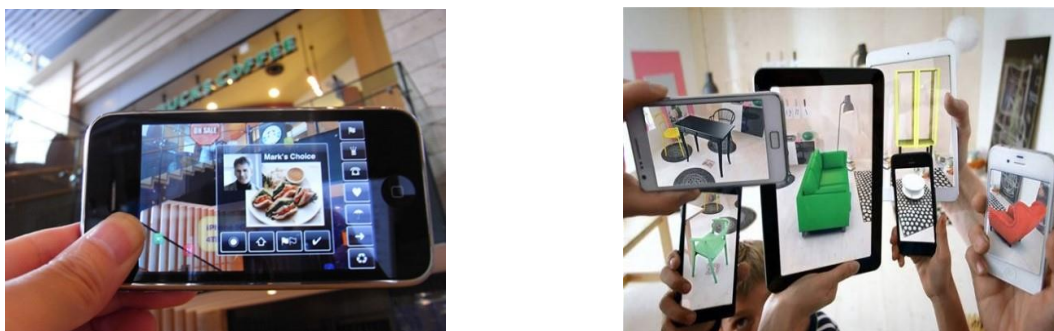

Figure 1. Mobile Augmentation and Augmented Reality using Images of Objects

A study on augmented reality, which creates a mixed reality by combining the actual world with a virtual world, began when Ivan Sutherland developed a see-through HMD (head mounted display) based on the actual world. Ronald Azuma's definition of augmented reality mentions a few key elements, through which a general meaning of augmented reality can be obtained. An augmented reality system combines real images and virtual images and enables real-time interaction. Augmented reality is implemented within a 3D space [7].

Augmented reality technology that extends real space-based information by integrating virtual images has been utilized in various areas. Such augmented reality technology can be applied to diverse real environments, such as location recognition, organism recognition, artificial intelligence, materialization of the five senses and mobile technology. Augmented reality has become popular as a next-generation display technology, particularly suitable for ubiquitous environments. The examples in Fig 1. show mobile augmentation of objects, and augmented reality using images of various objects.

2.2 Digital Clothing and i-Fashion System

The goal of digital clothing technology is to reproduce clothes in 3D using CG. Therefore, digital clothing technology has the potential to advance electronic innovations in fashion. Clothing production methods can be divided into analog, semi-digital, and digital methods. The analog clothing method employs conventional fashion design and garment manufacturing techniques, using panel (pattern) production to produce clothes by cutting and sewing the prepared panels. Semi-digital clothing methods integrate digital technology into various analog clothing processes. With this system, fashion design is conducted with design CAD software, and panel production is achieved with pattern CAD software. Digital clothing methods combine a 3D garment reproduction technique with the semi-digital method. With the addition of this new technique, garment design problems can be identified prior to the manufacturing process, allowing corrections to be made to the panels. Thus, digital technology has shortened the fashion item production process, and has been used for the planning of various products [8]. Fig 2. shows a digital clothing dress production method, with a computer-based dress reproduction stage added to a semi-digital method.
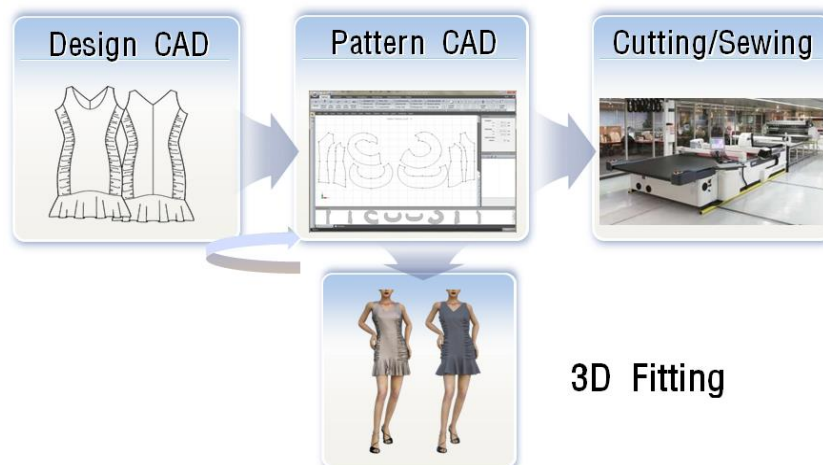
Figure 2. Digital Clothing Process for Producing Clothes

The i-fashion system shows the results of an avatar-fitting simulation program. It shows a full CG of a user's body on a large display, captured using a 3D whole-body scan of the user. i-fashion technology can be categorized as a 3D dress drape simulation

system. This system provides a technique to reduce the time necessary for actually producing clothes; moreover, various physical characteristics of clothes that would not otherwise be detectable can be checked quantitatively through simulation. The i-fashion system aims to establish the technology necessary for planning, designing, producing, and marketing clothes, by combining textile and fashion expertise with technology. i-fashion's goal is not to simply combine IT with fashion, but to create a new clothing marketing method. i-fashion can facilitate production by utilizing human body models and drape simulation over the web, using tools such as ActiveX and Java. However, Fig 3. illustrates that scanning for the display can take a significant amount of time during a department store presentation, and how a sense of unity is diluted when user images are expressed through CG [9,10].

Figure 3. i-fashion Department Store Presentation

## 3. Augmented Reality-Based Magic Mirror Fashion Coordination System

Augmented reality technology synthesizes images of virtual objects with real world scenes. Existing fashion coordination systems employ a virtual environment and QR codes. This study proposes a coordination system that can effectively coordinate diverse fashions that fit the user's body, using an augmented reality-based magic mirror. When the coordination system is not activated, an unaltered image of the user is displayed. When the user approaches or touches the display, they will activate the coordination system. The information expressed on the screen is composed of real-time 3D outfits, make-up, and a hair simulation function, which can immediately provide the fashion information requested by the user.

Hair design involves the overall practice of planning a new hairstyle. Morphological characteristics such as length, color, and wave are all elements of hair design. Formal characteristics such as order, balance, and harmony are also applied to the principles of hair design. Objectivity properly creates beauty by ordering some design elements through its principles. Hair color can change a person's image by increasing or decreasing the volume or making up a skin color. It can also establish a hairline for a person's face. Using bright and warm colors on the parietal area or bangs creates an effect that makes the subject's face appear longer. When dark and cold colors are used on the side of the head, it narrows the apparent length. However, when bright and warm colors are applied to the same point, it makes the subject's face appear wider. Hairstyle color changes play a very important role in overall impressions by focusing peoples' eyes. Various colors can be selected according to the preferred image and season, using the general characteristics of the individual colors. The hairstyle's texture can be made more natural or artificial by

applying styling techniques and pictorial color changes. Users can employ their own texture or combine it with others, depending on their personality.

The magic mirror fashion coordination system features mirror-like display processes that utilize user recognition, face styles, make-up, and dress fitting simulations. An edge detection method was required to facilitate user recognition. Canny Edge, Laplacian, and LoG (Laplacian of Gaussian) are representative edge detection methods. The Canny Edge method eliminates image noise using a Gaussian mask, and calculates leaning and strength with x and y axes. A strong point of the Canny Edge method is that it can extract strong edges that are not sensitive to noise. A method of extracting edges through the first order derivative shows sensitive reactions to vertical lines and diagonal lines. To supplement this, the second order derivative searches for closed curve-shaped edge contours. The second order derivative algorithm has Laplacian and LoG (Laplacian of Gaussian) in general. Laplacian extracts edges from all directions. Because Laplacian extracts edges using differences in the surrounding lightness, it cannot effectively reduce noise. LoG applies Gaussian smoothing after Laplacian detection to effectively remove noise. Noise can be removed and edges can be stressed by applying LoG in general. However, filtering results will change according to the size of the standard deviation.

The facial image captured by the camera can be significantly affected by various external environmental factors. To mitigate these factors, a face detection method that provides robust and fast computations is required. Haar-like detection features were used as the set of characteristics for object detection. Haar-like features can be computed quickly using the integral image. Haar-like features and the integral image can be used effectively in real-time object detection situations that require a reduction in complex operations, and high detection performance. Fig. 4 shows the representative Haar-like features, which are classified as edge features, line features, and center-surround features.
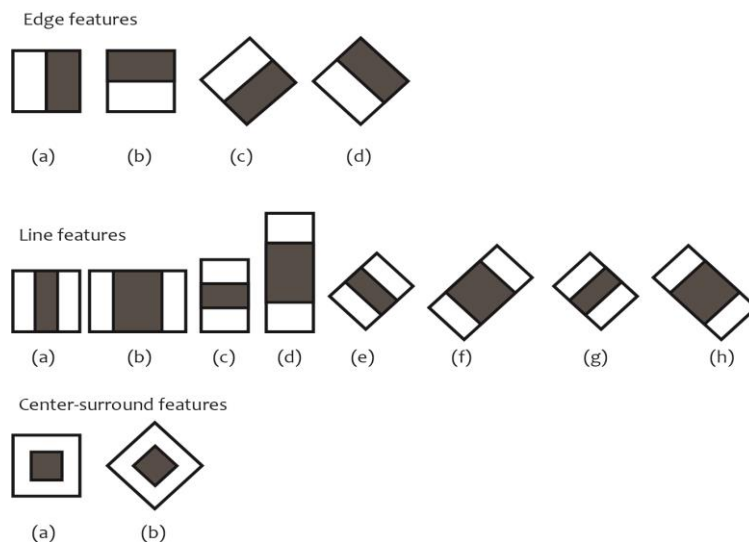

Figure 4. Haar-like Features from the OpenCV Source Distribution

In the most basic edge features, the feature value of (a), (b) is represented by the difference between two sums - the sum of all pixel values in the bright area and the sum of all pixel values in the dark areas. (c) can be obtained by calculating the difference between the sum of all pixel values in the outside bright area and the sum of all pixel values in the central dark area, and (d) can be obtained by calculating the difference between the sum of all pixel values in the bright area of the diagonal direction and the sum of all pixel values in the dark area.

$$ii(x, y) = \sum_{x' \leq x, y' \leq y} i(x', y') \quad (1)$$

In equation (1) ii(x, y) is the integral image, and ii(x′, y′) is the brightness value of the initial image. Point 4 (x, y)'s value can be obtained from all cumulative pixel values to the horizontal x coordinate, and to the vertical y coordinate. In Fig. 5, the sum of the pixels within rectangle D can be computed with four array references. The value of the integral image at location 1 is the sum of the pixels in rectangle A. The value at location 2 is A + B, at location 3 it is A + C, and at location 4 it is A + B + C + D. The sum within D can be computed as 4 + 1-(2+3) [11].
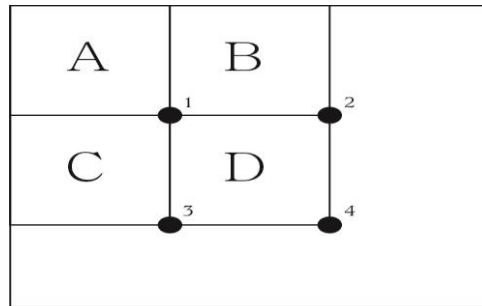
Figure 5. Rectangular Regions of an Integral Image

In the face styling and make-up stages, hairstyles are a key factor in increasing the level of perfection for fashion coordination. There have been many diverse hairstyles influenced by current trends and individual preferences; however, they have developed in relation to clothes. The basic purpose of hairstyles is to grant aesthetic effects to faces, based on the individual's facial features. Hairstyles are the most effective means for achieving these effects. Because a hairstyle is a means to produce an aesthetic symbol, it creates a new trend in the accompanying aesthetic values, human cultures, and time flows. Basic hairstyles include a solid form, a graduated form, an increased layer form, and a uniformly layered form. Fig 6. shows the solid form and graduated form.

Figure 6. Solid Form and Graduated Form

Figure 7. Increased Layer Form and Uniformly Layered Form

In the solid form, the hair gets longer from the exterior (crest lower hair) to the interior (crest upper hair). Hair drops to the same height without cutting, and imparts an inactivated feeling. The weight of the edges is formed in the lower part of the hair, resulting in an angular line. In the graduated form, the hair gets longer from the exterior (crest lower hair) to the interior (crest upper hair), and hair's ends appear to be overlapping one another. As a result, the activated feeling of the exterior and the inactivated feeling of the interior become mixed. A sense of the weight from the graduated form appears on the outline of the edge hairs. The graduated form tends to create a triangle. In the increased layer form, hair gets longer from the interior to the exterior; consequently, a completely activated surface feeling is created, without showing weight. The increased layer form results in a longer hairstyle.
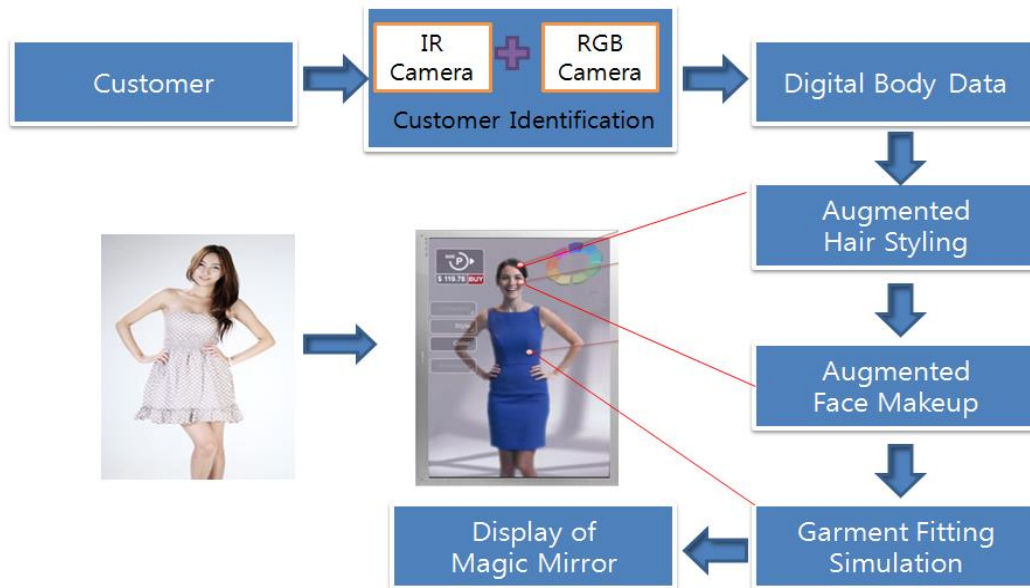
Figure 8. Configuration Map of the Augmented Reality-based Magic Mirror Fashion Coordination System

In the uniformly layered form, the length of hair does not generally show an even weight line. Hair is dispersed following the curve of the head, creating an activated feeling in general. The round shape of the uniformly layered form is parallel to the head curve. Fig. 7 shows the solid form and graduated form, which are basic hairstyles. In the face styling and make-up stages, face outline images are extracted from the user's photo images, and augmentation is performed by synthesizing extracted images and hairstyle images. The magic mirror system produces a fitting simulation that reflects the user's

physical characteristics. As a result, it appears that temporal synchronization of the user images and CG images is seamlessly performed.

The magic mirror's smart fitting fashion coordination component provides practical spatial functions; it also enables consumers to save time and reduce physical effort. Consumers can quickly select items that are suitable for them without trying on different garments. Fig. 8 shows a map of the augmented reality-based magic mirror fashion coordination system.

4. Conclusion and Future Tasks

The existing fashion industry depends on 2D images to design clothes, and does not adequately consider the physical characteristics of consumers. This study proposed a system that uses a depth camera to capture the figure of a user standing in front of a large display. Subsequently, by integrating fashion communication and augmented reality technology, the system can show a fashion concept to the user along with various outfits coordinated with his or her body; thus, a magic mirror effect is produced. With the coordination system turned off, the system displays an unaltered image of the user. A user approaching or touching the display will activate the coordination system. The information expressed on the screen is composed of real-time 3D outfits, make-up, and hair simulation functions, which can immediately show the fashion information required by the user. This 3D fashion mirror is a natural system. When no one is using this mirror, it automatically changes to mirror mode and performs the function of a typical mirror. When the magic mirror fashion coordination system creates a fitting simulation reflecting the user's physical information, it produces new and emotive images; this advanced capability should enable the system to keep pace with the digital design era and assume the role of a leading simulation information system. The proposed system is expected to enhance user convenience, and will be utilized as a customized clothes-shopping method in the near future.

As a future task, a convergence-type fashion coordination contents system will be developed by adding real-time customized fitting functions that apply VCA (Video Content Analysis) technology. For this purpose, new shopping culture innovations will be established by integrating the technique into offline stores.

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