Modular Redesign Process Based on 3D Digital Technology for Upcycling Apparel Design

Kyung-Hee Choi, Hansung University, South Korea

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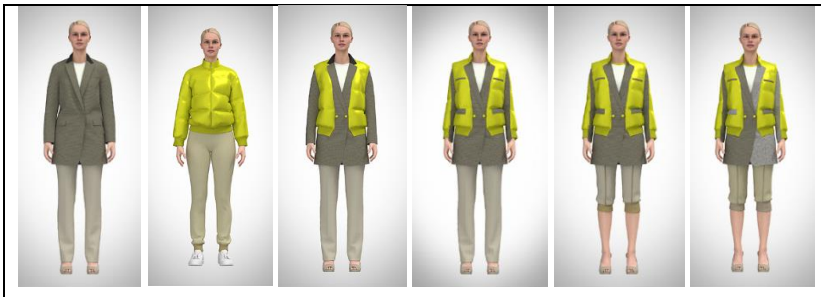
Digital transformation has been bringing innovative changes to the overall systems in the apparel industry. As the combination of the apparel industry and digital technology has accelerated alongside post-COVID-19, it is becoming an inevitable reality for designers and consumers to transcend the boundaries between real and virtual garments and to experience the convergence of online and offline in everyday life. This study aims to propose an alternative system, a modular redesign process using 3D digital technology to help overcome the confinements of the current redesign process of garments and contribute to providing up-cycling designers with creative and efficient design processes in the apparel industry. For this purpose, as a literature review, the researcher first examined the concept, types, and characteristics of modular design in apparel design, then identified the redesign process of garments and the limitations of the current redesign process, and finally investigated 3D digital technology in the apparel industry, focusing on the sustainable features of 3D virtual simulation systems. As the technical method to develop the modular redesign process, the researcher used 'CLO 3D' and 'Aftereffects' to create virtually redesigned garment samples based on the modular system by disassembling different virtual garments, assumed to be original materials and reassembling them in various ways to explore the sustainable potential of the modular redesign process.

A modular design is a system subdivided into small standardized units called modules, which can be independently combined, detached, and replaced with other units to create different configurations. In apparel design, modular design not only provides an experimental approach and creative means for transformable garments (Hur & Thomas, 2011) but also helps to achieve sustainability by redesigning garments (Chen & Li, 2018; Ribeiro et al., 2014). A redesign is defined as the upcycling of used, discarded, or unsold inventory materials to extend the lifecycle of a garment and add environmentally friendly value (Choi & Kim, 2018). Janigo & Wu (2015) summarized the main parts of the redesign process as Ideation - Garment Construction - Fittings. Unlike the conventional apparel design process, designers must consider several problems and constraints in the redesign process (Choi, 2019; DeLong et al., 2017). In particular, as inspiration sources in the ideation stage are concentrated on raw materials rather than sketches, designers' free design ideas can be reduced, and the types and amounts of available materials can be limited. In addition, designers usually require considerable time and effort to solve the problems in the construction and fitting stages. Meanwhile, 3D technology could enable designers to easily express their creativity and contribute to solving complex problems in design fields (Bonnardel & Zenasni, 2010; Yang et al., 2018). As 3D virtual simulation systems can provide apparel designers with an immediate interaction between 3D simulations and 2D patterns of a virtual prototype (Choi, 2022), they have reduced the need to develop multiple physical prototypes in the apparel design process (Porterfield & Lamar, 2017). As prior studies have shown a lack of

research on the 3D prototype development of modular redesign that links virtual and real garments or on a modular redesign process incorporating 3D digital technology, the modular redesign system based on 3D digital technology could suggest to apparel designers an effective approach toward their redesign process.

For the experimental explorations, ten modular redesign garment samples with the concept of 'My Closet: Modular Redesign' was created by modularizing original garments in a virtual closet composed of 3D virtual garment files (zprj and png) of CLO3D. The original garments for upcycling were chosen, focusing on more than two basic items from unused or discarded physical garments. Based on a garment panels-based modular system (Mansour, 2017) or a component modular design (Chen & Li, 2018), the modular design used in this experiment focused on disassembling several panels or parts which are removable and reassembling with other parts from the original garments and additional materials to solve some size or aesthetic issues. The final upcycling garments through the modular redesign process were completed with a unique and deconstructive women's ready-to-wear collection, which included different styles, details, textiles, colors, and even sizes. A more specific technical process is as follows (Figure 1-2): 1) Two original virtual garments for upcycling were produced from basic templates using CLO3D. The original garments (OGs) comprised formal suits and casual items (Figure 1a-b). 2) In the 2D pattern view of CLO3D, each module based on patterns and parts out of the OGs was disassembled and reassembled with other parts (Figure 1c-f). The redesigned garments (RGs) showed the modular redesign process of various design combinations in the bodices (Figure 1c), the details, including sleeves, collars, and pockets (Figure 1d), the pants (Figure 1e), and the fabric replacement (Figure 1f). 3) Aftereffects created a video clip to show the versatile and transformative modular redesign process (Figure 2). In addition, employing the Modular Mode of CLO3D, the garment modules produced or transformed through the modular design process was saved into a database for reuse in the future.



a. OG1 b. OG2 c. RG d. RG e. RG f. RG

Figure 1. A modular redesign garment from two original garments (OG) to redesigned garments (RG)

Figure 2. A video clip showing the modular redesign process

(hyperlinked to Google drive)

Figure 1-2. An example of upcycling apparel design through the modular redesign process

The findings from the experimental design are as follows: First, as the modular redesign process allowed designers a wide range of design ideas and transformations in styles, details, textiles, colors, and sizes, it expanded the scope of designers' experiments and enhance their creativity, especially in the ideation stage before the physical garment construction. Next, as the database of 3D virtual wardrobes, composed of garment modules, provided designers template-based design reservoir, it enabled designers to reduce the time and effort for redesigning garments through simulating practice-led redesign in advance in the ideation stage. Finally, since the 3D virtual simulation systems calculated the number of materials to be redesigned, the problems due to material restriction could be predicted before the construction and fitting stages.

As a result, developing a modular redesign process that integrated modular ideas and garment redesign with 3D digital technology proposed sustainable possibilities by providing apparel designers with an efficient design method with a template-based reservoir against the limitations of the current redesign process. As a future study, it would be necessary to evaluate the efficacy of the modular redesign system, aligned with the current state of the redesign process and designers' technology adoptions through in-depth interviews with upcycling apparel designers in the real industry.

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