Modular Illusion

Chanjuan Chen, University of North Texas, USA

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As a type of transformable fashion, modular design refers to clothing that have detachable or replaceable components, so that one can alter the clothing to an infinite number of combinations (Koo et al., 2014). Due to the versatile nature, modular designs have the potential to encourage consumers to buy fewer clothing items and therefore reduce the amount of waste generated. While designers can use the modular concept to create more sustainable garments, one concern of modular design is the durability of modular pieces following use. Many designers have explored the potential use of textile modules to create ready-to-wear or wearable art modular garments (e.g., Tucker, 2015; Hur, Cassidy, & Thomas, 2013). As most modular garments are made of fabric with nonfraying edges, such as felt and neoprene, the interlocking system of the modules can be worn out easily after frequent use. Additionally, depending on the fabric the garments are made from, different types of waste can be generated during the textile manufacture process and the garments may not be recycled and reused easily (Fletcher & Grose, 2012).

In recent years, 3D printing technology rapidly gained notoriety by apparel designers due to its ability to create complex shapes while reducing some of the subtractive manufacturing constraints and the enormous material wastes (Sun & Lu, 2015). 3D printing uses less raw materials because only the designed and necessary parts are manufactured and most of the printed filaments can be recycled for reuse (Lim and Cassidy, 2014). 3D printers have become more accessible, with technology on commercial desktop printers such as Fused Deposition Modeling (FDM) 3D printers. Flexible and elastic 3D printing materials such as thermoplastic polyurethane (TPU) filament also provides designers unlimited opportunities to explore fabric-like textures for creative designs (e.g., Lee and Li, 2021; Sun, 2018). However, few examples have been found from the literature review regarding the use of 3D printing technologies for modular designs. Previous studies by the researcher have explored modular design with 3D printed PLA components. The purpose for this design research is to explore modular design with 3D printing technology using an FDM printer with flexible TPU materials.

The inspiration for this design originated from optical illusion art titled I Ker by Victor Vasarely (1980). The work consists of black and white dotted and square patterns formed on a minimalistic and geometrical optical motif. The design interpreted this art by incorporating the changing properties of dots into each 3D printed module panel. A total of 17 modular panels were used to form this design. All panels were interlocked together without the use of a sewing

machine, forming an asymmetrical A-line top. The design can also be changed into a different looks through the modular function.

The process to create this design started by designing and sketching the ensemble. A loose A-line top was chosen to present the visual impact of the optical illusion. The modular unit was then developed on Adobe Illustrator. A circle was used as the base of the module to mimic the dotted motif found on the inspirational picture. Dots were also used as an optical illusion motif and applied to the module as cut outs. Opposite slots were added on the outer edge of each module forming a hexagonal position to add functionality to the module. This method references the system developed by Hur and Thomas (2011), in which placing an equilateral shape such as a

triangle or a hexagon inscribed within a circle to create tabs and slots for an interlocking system. However, after 3D printing the first set of samples with a TPU filament, the assembling process was time-consuming due to the large number of tabs and slots from each module in order to create the desired loose silhouette. After several iterations with the module unit design, a modified module unit was created by interconnecting seven circular modules from the initial unit (Figure 1). This enabled a larger module unit to be used for creating the design while maintaining equal tab and slot size for interlocking.

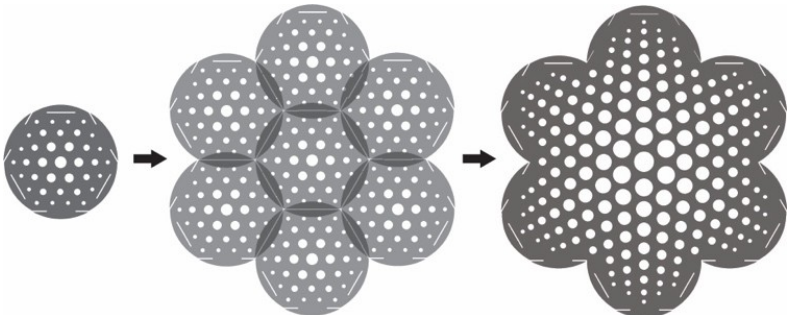

Figure 1. Initial unit (left) and modified module unit (right).

Once the shape of the module unit was finalized in Adobe Illustrator, the shape was then imported in Tinkercad, an online 3D modeling program, to create the 3D model. A slicing application called Cura was used to convert the 3D model into several thin layers suitable for 3D printing. A FDM 3D printer was used to print a total of 13 black modular panels and 4 white modular panels using TPU filaments. Each modular panel was 0.6mm thick and light weight, resulting in flexibility and comfortability for wearers. All modular panels were then interlocked together using the predesigned tabs and slots without the use of a sewing machine or adhesive. Lastly, a white tulle skirt with an elastic waistband was created to complete the ensemble.

The modular concept allows the wearer to create endless possibilities. Though an A-line top is adopted for this design, the design can be changed through rearranging the placement of the black and white modular panels or altering the combination of the units in order to change the silhouette. By taking inspiration from optical illusion art, the design can be easily dressed up or down pairing with different types of pants/skirts, presenting a visual impact in all views.

Through modifying the modular unit, the design could be easily transformed to provide a bigger section of coverage for any long or loose designs. In addition, the integration of 3D printing technology into modular design allows for easy configuration and editing of designs while increasing the module design's durability. The 3D printed modules' interlocking ability can stay functional over numerus actions of connecting/disconnecting. The 3D printed modular units are stronger than common fabric units. As most of FDM printers have limited printing bed size, most designers print out sections of their designs and assemble them together to form a larger size textile, such as the 3D printed collection created by Danit Peleg, one of the first fashion designers to create commercially available 3D printed clothing (2018). Since the modular design is formed by slotting together without sewing, the challenge of printing a whole garment without the use of adhesive or a sewing machine can be achieved. The outcome of the design achieved the goals of creating a loose modular design with 3D printing technology using an FDM printer with flexible TPU materials. This piece adds knowledge to the existing body of work regarding transformability in modular design with the use of 3D printing technology with flexible material.

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