Consonance of 3D Printed Fiber Network

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Contextual review and concept statement. With the enhancement of digital design and manufacturing technologies, 3D printing (3DP) has attracted much attention from the fashion industry (Cui et al., 2021; Kim et al., 2019; Lee, 2022; Spahiu et al., 2020). Researchers have explored the potential use of 3DP in wearable art and integrated 3D printed textiles into the wearable product design and development (Sun, 2020). However, 3DP has been mainly applied in a small section of wearable product design, using rigid materials and certain 3DP methods. For example, Nervous System's (2014) Kinematics dress was created with repeated interlocking 3D printed panels using selective laser sintering 3DP method with rigid materials. The rigid interlocked structures often prohibit flexibility, drapability, and stretchability of 3D printed textiles, which greatly influence wearers' comfort and function (Lee, 2022). Although previous studies have explored alternative pattern structures in developing 3D printed textiles for wearables (e.g., Cui & Sun, 2018; Kim et al., 2019; Lee & Li, 2022; Sun, 2018; Sun, 2017; Uysal & Stubbs, 2019), little attention has been given to develop 3D printed seamless textiles to replicate traditional lace structured textiles, which may provide better wearability to wearers. Therefore, we challenged to develop a seamless 3D printed design, consisting of a high waist skirt and a sleeveless vest, showcasing high drapability of 3D printed textiles. For this textile innovation challenge focusing on 3D printed textiles' drapability, the design, *Consonance of 3D Printed Fiber Network*, was proposed using fused deposition modeling (FDM) 3DP method with thermoplastic polyurethane (TPU) filaments.

Aesthetic properties and visual impact. The silhouette of this design was inspired by traditional oriental costumes (e.g., Korean hanbok, Chinese hanfu), which is ideal to present the high level of drapability. The simple silhouette with a delicate flow of curvy lines represents the elegance of traditional Asian costume's aesthetics and the thought of harmony rooted in Asian culture. The lace structures of 3D printed textiles were derived from two most popular Asian flowers, sacred lotus and water lily, which embed the symbolic meaning of purity and eternity. For example, as shown in Figure 1, all of the petals are connected and arranged symmetrically with a proper balance, which possess a simple structural beauty with consonance. The sleeveless vest, layered with two of water lily inspired 3D printed textiles, was designed to fit the upper body tightly with 3D printed snap buttons as closure in the front. The high waist skirt composed of two layers of 3D printed seamless textiles with two different lengths. This two-layered gathered skirt was hand sewed together with a waistband made of a naturally dyed silk fabric; this waistband reflects the color of sacred lotus and allows

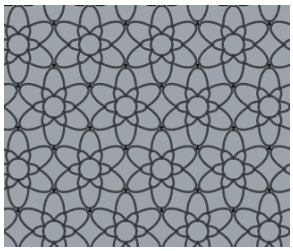

Figure 1. Sacred lotus pattern motifs

wearers to adjust the tightness of this skirt, which adds additional oriental aesthetic and functional values. By using flexible TPU filaments, 3D printed seamless textiles with the lace pattern can be freely stretched and draped, which allow the unrestrained body movement for wearers.

Process, technique, and execution. The design process consisted of six iteration stages: design ideation, 3D lace pattern structure development and testing, 2D pattern development and 3D stimulation, segmenting and 3D modeling, 3D printing, and assembly including trimming of 3D printed panels. The design began with brainstorming of the outfit, consisting of the high waist skirt and the sleeveless vest. Then, the lace patterns of lotus and water lily were developed, and arrangements of the petals were tested and determined. 2D skirt and vest patterns were created, virtually draped, stitched, and adjusted on a size 8 female avatar in CLO; the contour lines of the 2D patterns were exported and then imported into Rhino for segmenting the design and fabricating the 3D model of each panel. Two layers of the 2D vest pattern were segmented into 24 panels and water lily motifs were embedded in each panel with 0.4mm extrusion. For the skirt, a total of 140 panels were segmented and inserted with sacred lotus motifs (see Figure 1). A FDM 3D printer was used to print total 164 panels with black TPU filaments. Figure 2 presents the 3D printed seamless textile for the two-layered gathered skirt. We spent 11 weeks on designing the skirt and the vest, including two weeks of design ideation, four weeks of experimenting 3D textile pattern structures, three weeks of 2D pattern development and 3D segmenting, and two weeks of CAD modeling. For 3DP, a total of 159.5 hours was spent to print the 164 panels (17.5 hours for the vest and 142 hours for the skirt). Additional 15 hours were spent to trim the 3D printed panels and assemble each panel seamlessly. All panels were joint together using a permanent liquid fabric adhesive and then the waistband was lastly hand sewed to the skirt. This design is much lighter than the one made of traditional lace fabrics with a weight of 55g for the vest and 349g for the skirt, which provides better comfort to wearers.

Figure 2. The 3D printed seamless textile for the skirt

Cohesion. This design, *Consonance of 3D Printed Fiber Network*, is the outcome of our 3D printed textile innovation challenge, especially focusing on the seamless joint process of 3D printed panels and drapability of the newly developed 3D printed textile (see Figure 3). The 3D printed textiles simulated traditional lace structured fabrics and the design, consisting of the high wait skirt and the sleeveless vest, well illustrates functional, expressive, and aesthetic values. The inspirations from traditional oriental costume's silhouettes and floral inspired lace patterns enabled us to amplify the visual rhythm of this 3D printed design with a seamless flowing effect. The simple silhouette and 3D printed pattern structures enhance drapability of the 3D printed textiles we developed, which maximizes wearers' function and comfort.

Significance, rationale, and contribution. With the flexible 3DP filament, lace structured patten, and seamless adhesive joint method, 3D printed textiles in this design were created to replicate traditional lace structured fabrics, considering high drapability. The design created by using this novel 3D printed seamless textiles reveals the great potential of 3DP for designing and developing wearables in fashion.

Originality and innovation. This design is original and innovative at (a) developing 3D printed wearable textiles with traditional oriental aesthetics, (b) identifying and applying the seamless adhesive joint method, and (c) integrating novel digital design and manufacturing technologies for developing wearables considering their high drapability when wearing.

Figure 3. Textile innovation with 3DP

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References

Cui, T., & Sun, L. (2018). Hybrid comfort: 3D printing interwoven, *International Textile and Apparel Association Annual Conference Proceedings, 75*(1). https://www.iastatedigitalpress.com/itaa/article/id/1311/

Cui, T., Chattaraman, V., & Sun, L. (2021). Examining consumers' perceptions of a 3D printing integrated apparel: A functional, expressive and aesthetic (FEA) perspective. *Journal of Fashion Marketing and Management, 26*(2), 266-288. https://doi.org/10.1108/jfmm-02-2021-0036

Kim, S., Seong, H., Her, Y., & Chun, J. (2019). A study of the development and improvement of fashion products using a FDM type 3D printer. *Fashion and Textiles*, *6*(9). https://doi.org/10.1186/s40691-018-0162-0

Lee, Y. A. (2022). Trends of emerging technologies in the fashion product design and development process. In Y. A. Lee (Ed.), *Leading edge technologies in fashion innovation: Product design and development process from materials to the end products to consumers* (pp. 1-16). Palgrave Macmillan.

Lee, Y. A., & Li, Y. (2022). Bouncing with 3D printed soft cells, *International Textile and Apparel Association Annual Conference Proceedings, 78*(1). https://doi.org/10.31274/itaa.13291

Nervous System. (2014). *Kinematics dress*. https://n-e-r-v-o-u-s.com/projects/sets/kinematics-dress/

Spahiu, T., Canaj, E., & Shehi, E. (2020). 3D printing for clothing production. *Journal of Engineered Fibers and Fabrics*, *15*. https://doi.org/10.1177/1558925020948216

Sun, L. (2017). Daring to sprint: 3D printing textile, *International Textile and Apparel Association Annual Conference Proceedings,* 74(1). https://www.iastatedigitalpress.com/itaa/article/id/1738/

Sun, L. (2018). Instilled: 3D printing elastic lace, *International Textile and Apparel Association Annual Conference Proceedings,* 75(1). https://www.iastatedigitalpress.com/itaa/article/id/1355/

Sun, L. (2020). 3D printing technologies: Current applications, future trends, and challenges. In J. Yip (Ed.), *Latest material and technological developments for activewear* (pp. 139-151). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-819492-8.00007-7

Uysal, R., & Stubbs, J. B. (2019). A new method of printing multi-material textiles by fused deposition modelling (FDM). *Tekstilec*, *62*(4), 248-257. https://doi.org/10.14502/tekstilec2019.62.248-257