Eclipse

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Introduction, concept, and context. With the advancement of technology, 3D printing (3DP) has attracted significant attention from the fashion industry (Cui et al., 2021; Spahiu et al., 2020; Sun & Zhao, 2017). For example, Danit Peleg (2017) incorporated the fused deposition modeling (FDM) 3DP method to develop 3D printed dresses. Li and Lee (2024) used thermoplastic polyurethane (TPU) filaments and 4D printing materials in 3D printed footwear design. Despite enormous possibilities in design and production, 3DP still primarily used in the fashion industry for producing small scale wearable accessories. Due to the limited printing volume capacity, most commercial 3D printers can only print small panels at a time, which then require manual assembly (Valtas & Sun, 2016; Yap & Yeong, 2014). The lack of effective joining methods in 3DP could significantly hinder its application in wearable product design and development.

According to Bogue (2007), joining methods are critical design criteria in developing wearable products. The method, joining seams among garment pieces, is essential to ensure that products are not only aesthetically pleasing but also functional, durable, and comfortable. A melting technique exhibits great potential as a joining method for fusing meltable materials in 3D printed wearable product development process (Valtas & Sun, 2016). For example, Sun and Valtasa (2019) used melting to fuse various 3D printed panels together, resulting in the creation of large scale 3D printed textiles. Previous studies have explored the potential of other joining methods used in 3D printed wearables' development such as using adhesives and special physical joining mechanisms (e.g., Spahiu et al., 2020; Li & Lee, 2022). However, limited attention has been given to explore melting as a special joining method used in 3D printed textile development, leading to the current design challenge. This 2D/3D wearable art, *Eclipse*, is the outcome through developing different types of 3D printed textiles using melting to mimic traditional sewing, showcasing wearability and drapability of 3D printed products.

Aesthetics. The inspiration for this wearable art was derived from the movement of eclipse, encompassing the phases from the initial obscuring to the eventual emergence of light. This 2D/3D wearable art, *Eclipse*, consists of two distinct visual art pieces. The first piece is a basic shirt in white with the 17" length, designed for kids, symbolizing 'light'. The other piece is a basic black shirt with the 29" length, designed for adults, representing 'shadow'. These two wearable pieces, differing in sizes and colors, were developed to portray the contrast between the darkened and illuminated areas during the phases of eclipse, thereby reflecting the transition from obscurity to light. As shown in Figure 1, two differently structured 3D printed textiles in both black and white were created for this design to capture the concept of transformation in eclipse. 3D printed plain textiles featuring rounded and lunate structured holes serve to represent the different eclipse stages. Moreover, 3D printed lace textiles with continuous eclipse patterns inspired by the shadow cast during eclipse convey the delicate interplay between opposing forces while evoking the concept of balance and harmony. An offset pattern arrangement was used to

layout the eclipse patterns, creating a dynamic and visually engaging effect. Melting used in the design assembly process visibly resembled stitch lines of sewing to effectively join 3D printed textile panels, which enhances visual interest and reinforces seam strength without compromising flexibility, ultimately improving wearability (see Figure 2).
Methods: Process, technique, and execution. The design process began with ideation and pattern development. Initially, 3D printed textiles with different textile structures were designed and tested. Two basic shirt patterns were developed and virtually simulated using CLO 3D, using adult and kid 3D avatars as the basis. The contour lines of adult and kid's 2D patterns were exported and converted in Rhino to build 3D models for each shirt. The proportion and shape of two differently structured 3D printed textiles were subsequently refined to achieve visual balance in the final design using Rhino. Using the line tool in Rhino, different eclipse patterns were created and embedded in each textile panel. The plain and lace structures were further segmented into a total of 64 textile panels, with 36 panels allocated for the shirt designed for adult and 28 panels for the shirt designed for kid (see Figure 3). All the textile panels were separately extruded into 3D models with a thickness of 0.2 mm to guarantee that the final design maintained sufficient flexibility, suitable for both wearing and displaying as visual art pieces. An FDM 3D printer was used to print all panels with TPU filaments. Printing adult and kid's shirt took 21 hours and 13 hours, respectively. An electrical soldering iron was used to fuse the textile panels together until 3D printed textiles formed bonds with each other. The assembly process for this wearable art, involving two shirts, took a total of 13 hours including an hour to trim and clean 3D printed textile panels and 12 hours to join all the 3D printed textiles using the melting technique.

Cohesion. Using various innovative design technologies such as 3D simulation and 3D printing with the melting technique, this 2D/3D wearable art showcases the viability of 3DP in revolutionizing design and production in the fashion industry. Incorporating the inspiration from the movement of eclipse, the design, *Eclipse,* consists of two 3D printed wearable shirts for both adult and child. It serves as a medium to convey visual expression of drapability and wearability, bridging the gap between fashion and art, while also fulfilling users' needs as everyday wearables and as visually striking art pieces for display.

Design contribution. By employing the melting technique, this 2D/3D wearable art emulates a traditional sewing technique in developing 3D printed wearable products. This design unlocks new possibilities for effectively joining 3D printed textile panels or seams. By integrating flexible 3DP materials and diverse textile structures, this design challenge highlights the potential of incorporating various 3D printed textiles in the development of wearable products, thereby satisfying users' functional and aesthetic needs. This 2D/3D wearable art is innovative and original at (a) portraying both practical and expressive aspects of 3D printed wearables in terms of wearability and drapability and (b) demonstrating melting as a potential joining method in developing 3D printed wearables, which provides valuable guidelines for future designers.

Figure 1. 3D printed textiles

Figure 2. Joining method

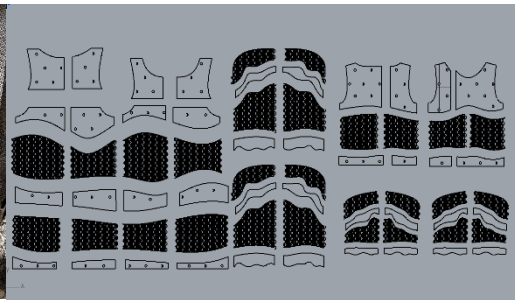

Figure 3. Wearable shirt segmentation

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