All 3D Garment Design and Development Processes for 3D Weaving

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Introduction: Garment development and production rely on the ability of the design team to effectively make a desired three-dimensional (3D) garment from two-dimensional (2D) textile shapes for a 3D body shape. This 3D to 2D to 3D transition takes time, education, and a great deal of tacit knowledge to execute efficiently and accurately (Arribas & Alfaro, 2018; Magnenat-Thalmann, 2010; Parker et al., 2021; Zhang & Little, 2018). Yet, at each part of the design to product cycle, there are issues found that impact customer satisfaction with fit and style. These include translating a 2D design image to a 2D pattern accurately, calculation of functional ease in a 2D pattern for 3D growth and compression and making style/fit changes based on 3D body shape (Ashdown & Loker, 2010; Istook, 2002; McKinney et al., 2017; Scott et al., 2019; Zhang & Little, 2018). Many of these issues originate from the complex use of 1D measurements to make 2D shapes cut into 2D material then bent and folded into a shape placed on a 3D object, the human body (Scott et al., 2019; Zhang & Little 2018). As Cottle, Ulrich, and Simmons (2014) discussed, this could be termed "the 3D-to-1D-to-2D-to-3D method of apparel fit". It is in the 2D pattern where the 3D body shape is flattened to the use of measurements, which do not reflect much of the subjective characteristics of the body (Magnenat-Thalmann, 2010; Scott et al., 2019), and leads to fit dissatisfaction as well as a desire for customization from the customers (Ashdown & Loker, 2010; Scott et al., 2019). Fit dissatisfaction can also lead to a significant percentage of garment returns which is wasteful and waste contributes to the planet-wide crisis of climate change (Gwilt, 2014; Hethorn & Ulasewicz, 2015; Papahristou & Bilalis, 2017; Robinette & Veitch, 2016). Design to garment processes and workflows have consistently been burdened by this 2D to 3D transition in the development and production processes (Magnenat-Thalmann, 2010). What if the whole process, from design to garment, was entirely 3D? In the present study, we propose a conceptual approach and the initial steps taken toward introducing a garment process that would produce a custom zero fallout garment by keeping the whole apparel process from design to production in 3D.

Conceptual Approach: In the proposed conceptual approach, we propose an entirely "3D garment design-to-product" workflow, which starts with a 3D body scan because accurate modeling of the human body is essential for good fit (Figure 1). Pants were chosen to test this concept because women frequently report fitting issues in bifurcated garments (McKinney et al., 2017). To accommodate for general fit ease a copy of the scan mesh can be offset overall an eighth of an inch. Using contouring tools on the offset scan in key places and in key directions, curves can be created to maintain measurement bust girth and height contour shapes. Through a process of creating, altering, and converting curves into surfaces, the fit and design of the pants can take shape. At the end of the design process, the designer and technical designer should have a whole fitted shape of the garment as a closed surface. Next, the garment would go into textile development and the yarns per inch can set the size of the required grid for a specific weavable quadmesh, i.e., a grid. The garment shape can be then separated into weavable pieces that can effectively fit within a tubular loom. In software programs such as Rhinoceros 3D, each piece can be re-meshed with a quadmesh that adheres to a set of rules that allow the piece to be weavable. Once the quadmesh grid is applied a black and white 3D "card image" can be generated by adding a checkerboard-like grid fill for plain weave, or a step-like pattern for a twill weave. Designing clothing in software similar to Rhinoceros 3D may prove to have advantages and disadvantages. Most of the disadvantages may be due to the program not being built specifically for garment design. The curves created directly from the contours of the scan can be too complex, with many control points for the program to viably calculate for a smooth or recognizable enough surface. Creating surfaces directly from the exact curves of the scan cannot be viable. However, simplifying the curves can lose the precise shape of the body, albeit by a very small amount, and designers may lose the exact alignment of intersecting curves, which can be problematic when creating the necessary surfaces. In order to employ the specific rules of a weavable quadmesh, a programmable add-on, such as Grasshopper, would be useful. The advantages however should out weight these setbacks primarily because the curves can generate a design paradigm shift in clothing design. Designers would be able to draw in the air or the space around a body with lines that would be based on the actual body. Ease then could be more precise to areas with direct access to the real 3D space left by the ease. Designers can see the impact of ease on the body in real-time without the iterative process of making samples.

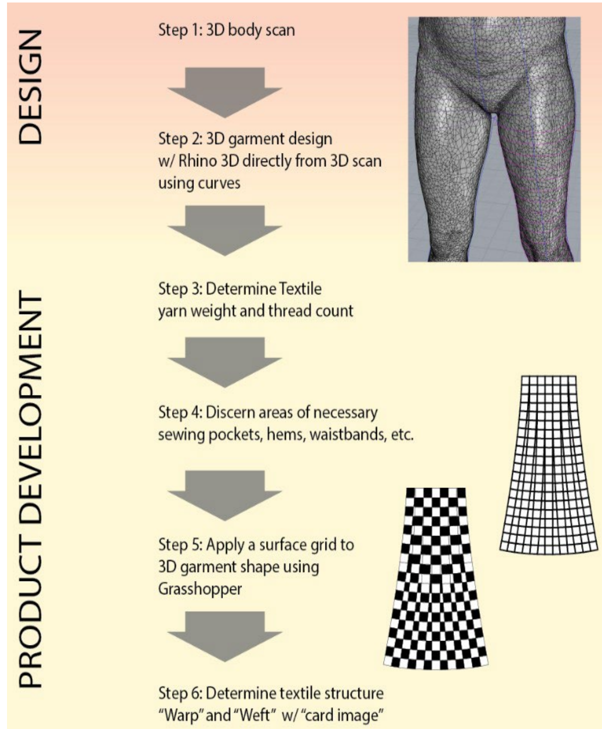

Figure 1 Proposed Workflow

Discussion and Implications: With the current and emerging 3D technologies, the specific limitations and abilities of software programs and machines need to be in conversation with the ways in which designers can 3D design garments. Without these conversations, the viability, aesthetics, and fit of a garment cannot effectively achieve what is desired in a garment. The pants designed in this project would ideally be woven on a tubular 3D weaving machine. 3D weaving has the potential to create precisely fitting and shaped garment pieces made without cutting room floor waste or the waste of excessive iterative samples. An all- "3D design-to-product" process would eliminate the 1D to 2D to 3D guessing game common with the use of flat fabrics.

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Figure 1. Proposed Workflow

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