SOFT BOUNDARIES: MAKING SPACES

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Abstract

The purpose of this interdisciplinary design project is to use digital computer numerical control (CNC) knitting technology to create spaces connecting us to our surroundings, allowing us to mould, hold, and thrive in our environments. The use of CNC knitting technology is furthering the legacy of craft and textile-making by combining the potential of algorithmic design and fabrication with handcraft's material sense and construction knowledge. A collaborative research process between architecture and apparel design is being used to produce digitally knitted items spanning scale and application to define spaces that personally connect the user or wearer to their environment while exploring human interactions with the micro and macro spaces in which they move. Functionally, textiles in architecture create spatial enclosures, and garments create body coverings, providing humans with protection from physical elements as well as psychological spaces used to conceal, protect, communicate, and take comfort within. This perception of space highlights how clothing and architecture can support each other as places people inhabit and can create both healthy and unhealthy human environments. This health is related to the impact the production of these products has on the environment as well as humans interacting with the objects. By working through process, values, and purpose within the design process a shift in approach to the use of materials and the relationship between the spaces we live within and the clothes we inhabit daily is formed. Reflection on the research completed thus far suggests that digital knitting and further interdisciplinary collaborations can be used to produce a highly tactile, transformable sense of space existing within a structure as well as an item of clothing.

Introduction

The purpose of this interdisciplinary design project is to use digital CNC knitting technology to create spaces connecting us to our surroundings, allowing us to mould, hold, and thrive in our environments. The use of CNC knitting technology is furthering the legacy of craft and

textile-making by combining the potential of algorithmic design and fabrication with handcraft's material sense and construction knowledge. A collaborative research process between architecture and apparel design is being used to produce digitally knitted items spanning scale and application to define spaces that personally connect the user or wearer to their environment while exploring human interactions with the micro and macro spaces in which they move (Figure 1). Functionally, textiles in architecture create spatial enclosures, and garments create body coverings, providing humans with protection from physical elements as well as psychological spaces used to conceal, protect, communicate, and take comfort within. (Albers, 1957) Occupation of these spaces can both empower and control the user. Similarly, clothing embodies space around a body and can direct how bodies move within spaces (Entwistle, 2001), while architecture and interior design create spaces through forms of enclosure that further define the body and its experience. This perception of space highlights how clothing and architecture can support each other as places people inhabit and can create both healthy and unhealthy human environments. This health is related to the impact the production of these products has on the environment as well as humans interacting with the objects. Supporting human well-being is an important component of this exploration of space.

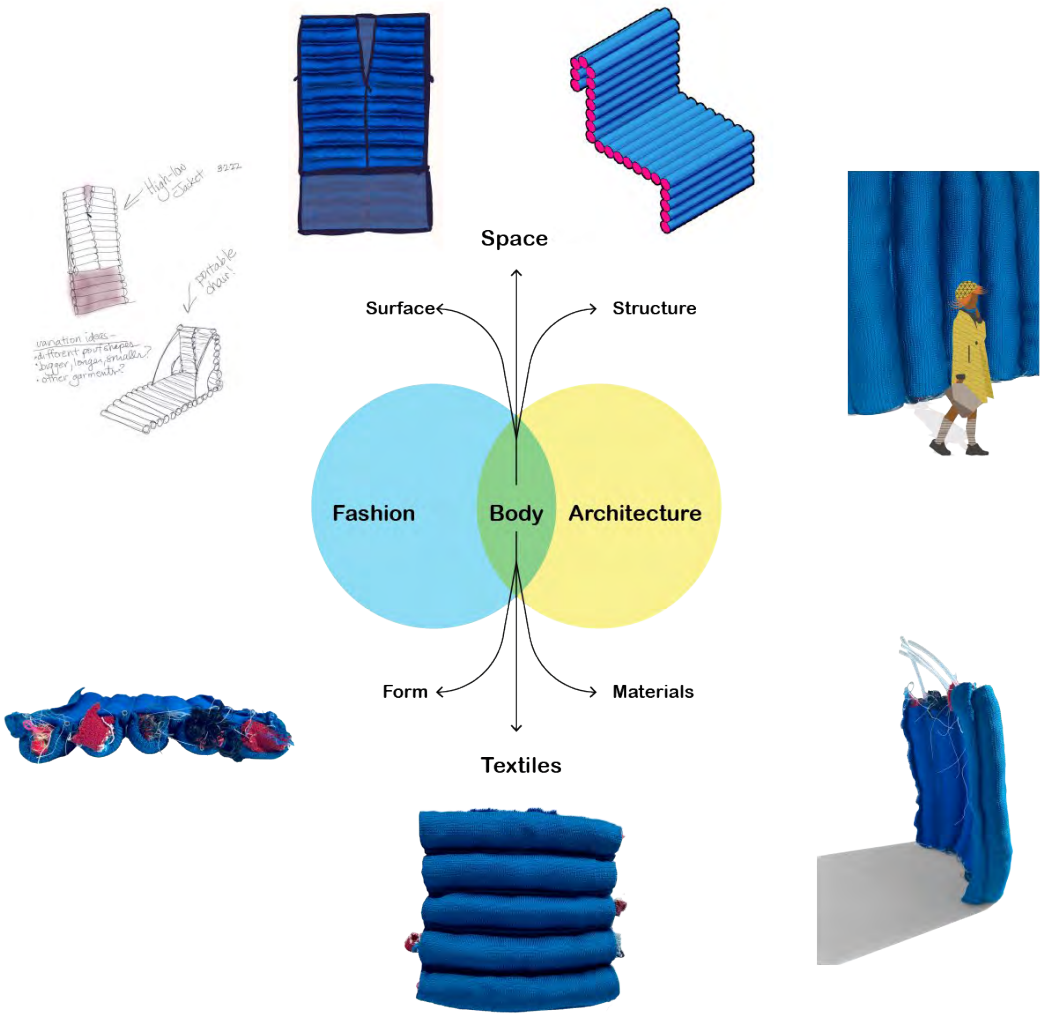

Figure 1. Interdisciplinary Research Process

Literature Review

Digital knitting is an ideal process to employ for this project, as it is an emerging technology capable of producing innovative textile products for apparel, architecture, interiors, automotive, safety, and medical applications (Blaga et al., 2011; Choi, 2005; Liu et al., 2017) The process combines the use of traditional craft techniques and material knowledge with advanced digital fabrication to produce transformative three-dimensional (3D) shaped textile objects that are designed and developed without the use of seams, allowing focus to be on shape, material properties, and tactile experience. Previous research using digital knitting machines for 3D shapes has established best practices to translate 3D concepts into two-dimensional programmable shapes (Hong et al., 1994). Unlike woven goods that must be cut and sewn producing significant waste (Power, 2012), 3D knitting produces exact shapes in specialized yarns and waste is minimized or eliminated. Specific characteristics can then be engineered within the 3D structures, such as spacers and plating, allowing for strength, stretch,

porosity, and even care properties such as non-wrinkle to be programmed into the textile without special finishes or construction (Onegina, 2017). The resulting shapes and tactile experiences are intrinsically intertwined with the materiality of the objects produced, linking the entire process to craft practice.

While a more recent addition to architecture and interior design research, digital knitting shows promise in material adaptability, customisation, and space-making (Liu et al., 2022). Digitally knit composite towers, tensile enclosures, and furniture are expanding the limits of textiles in architecture applications (Ahlquist, 2017; Liu et al., 2022). Potential knitted material use in architecture through form-making and structure is also being explored (Thomsen et al., 2016). In apparel, digital knitting has transformed the ability to develop fully-fashioned clothing and reduce resources required to produce products. To provide context to the apparel items in this project, it is important to note that the focus is on the function and the individual's response to the wearable pieces, rather than socially constructed notion of fashion garments (Kawamura, 2005). The object in service of the user as a protective, expressive, and functional object are the primary design objectives.

The practice-based methodology here seeks out innovative processes through the development of a body of work using "making as a way of generating design knowledge" (Loh, et al., 2016). This allows the process to operate as an "open system, one that is networked, responsive, and expanding" (Vaughan, 2019). The importance of digital tools in contemporary design and craft practice is now established as common, respected, and important (Nimkulrat et al., 2016). This relationship between the digital and physical environments is critical to effective use of technology, because the designer must interpret digital programming through the lens of material knowledge the computer does not possess (Albers, 1971; McCullough, 1996). When addressing a design challenge utilising digital and craft practice, it is important to condense the working space between tools and materials to address design problems with innovative solutions in an intertwined workflow (Riewe, 2021). How this affects the process and resulting objects produced are important considerations spanning technical, design, and artistic disciplines. This requires new skills, as the digital techniques must still be mastered as a new type of craft (Nimkulrat et al., 2016, p. 71).

Furthermore, even with rapid prototyping made possible, the expanded digital possibilities require additional exploration and sampling (Nimkulrat et al., 2016, p. 66). To fully explore digital tools and their ability to produce useful and aesthetically pleasing physical objects requires both skill and work, described well by David Pye's definition of workmanship (McCullough, 1996).

Methodology

Following a "research through practice" framework from textiles (Bye, 2010) and the "creative practice method" from interior design (Vaux and Wang, 2020), this work began with initial tests of digital knitting programming and production through the lens of material exploration, craft, and workmanship. Kudless was quoted in Vaux and Wang, "craft in the age of

computation is simply having a level of mastery over the tools and materials where you push them to their limits and the result is unknown from the start" (2020, p. 230). They note that this view resonates with David Pye's definition of workmanship: "using any kind of technique or apparatus, in which the quality of the result is not predetermined, but depends on the judgment, dexterity and care which the maker exercises as he works" (Pye, 1995, p. 20). This approach differs from other research with the technology in which textiles using digital knitting are used in service of a predetermined form (Ahlquist et al., 2014; Davis-Sikora et al., 2020). In this methodology, the research outcome is guided through the creative discovery process, which when using technology and craft-methods is often unknown and unpredictable. Introducing craft and textiles, such as knitting, to the fabrication process yields an element of suspense and the potential for constant changes and modifications throughout the process.

Initial testing into the capabilities of digital knitting to address functional, aesthetic, and sustainable needs of apparel and architecture was conducted separately by the two collaborating researchers, but the connections became apparent while they worked alongside each other developing extensive prototypes. The common research objectives were (1) the use of sustainable processes, (2) multi-functional products, (3) user comfort and (4) aesthetic appeal. Double-bed 3D digital knitting provided the tool to address these objectives through the near zero-waste production process and capability to engineer both visual and functional characteristics into the textile, and textile object. To fully capitalise on these capabilities, the researchers sought to develop a multilayered, 3D textile with both soft and structural characteristics. Extensive knit prototyping through iterative sampling led to the final development of a knitted structure with the appearance of a quilted panel or puffer jacket was selected (Figure 2). This structure consisted of exaggerated tubes that could be stuffed to increase the distance of the textile barrier off the skin or provide texture barrier to walls and interior spaces (Figure 3). The stiff yet soft textile product could be used in a variety of applications, such as wall panels, chair covers, or apparel such as a jacket, and visualizations in CAD and Clo 3d led to the final objects produced–a puffer jacket, chair cushion, and wall hangings (Figure 4). Additionally, Repreve™ (Unifi) yarn, recycled from plastic bottles, was chosen to knit the goods. By responding to the materials and processes throughout the design research, both sustainability and aesthetic appeal were achieved in developing products. Furthermore, the products can be repurposed, moved, transformed, or recycled again to extend their use or become part of a circular design process.

Figure 2. Quilt-like knitted fabric prototype

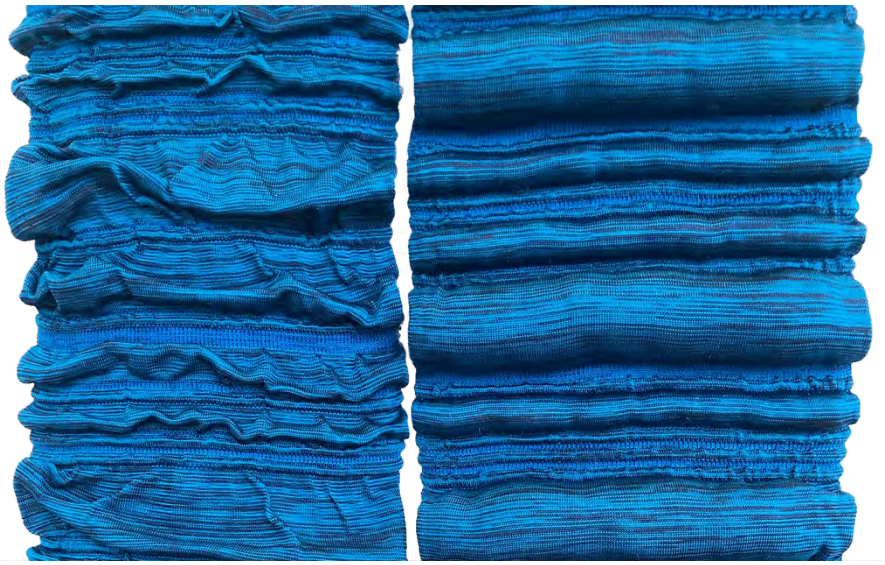

Figure 3. The selected knitted structure shown unstuffed (left) and stuffed (right).

Figure 4. Finished knitted objects (jacket, wall panel, chair cushion)

Analysis

By working through process, values, and purpose within the design process, a shift in approach to the use of materials and the relationship between the spaces we live within and the clothes we inhabit daily is formed; as Kate Fletcher states, we struggle to think beyond “our current experiences and imagine fabrics and garments in other configurations, with other agendas and possibilities” (2014, p. 240). Digital knitting introduces a combined process of textile product development and production with multifunctional purposes in a near zero-waste manner. Reflection on the research at this juncture suggests that digital knitting and further interdisciplinary collaborations with the process can be used to introduce more sustainable and even circular manufacturing methods to clothing and space design, as well as any industries requiring textile goods. The “act of making textiles is more than a series of steps on the road to new product development and innovation” (Valentine et al, 2017, p. 973), and the use of digital knitting offers the potential to develop significant sustainable transformation to industries that use textile goods by allowing the designer to imbed values of function and aesthetics into the product throughout the process. At the scale of the body and interior, sustainable retail, workplace, and apparel design through the application of these digitally knitted objects has an immediate impact on the reduction of materials and waste, as the components are reusable and

adaptable. Additionally, the programming process can be scaled or developed for specific spaces using digital methods, and structures can be transformable, modular, and multi-use, allowing them to be mobile and transitory. Reflection on this research suggests that digital knitting and further interdisciplinary collaborations can be used to produce a highly tactile, transformable sense of space existing within a structure as well as an item of clothing.

Looking Forward

Future projected outcomes of this research will test large-scale application of the stuffed textile system described here, with the goal of creating immersive environments that respond to the needs of the user through the incorporation of hybrid apparel and spatial elements. We plan to work towards expanding people's awareness of the importance and power of space on our individual and collective well-being, and to challenge and expand the capabilities of digital knitting to produce transformative textile objects. To do this, we will produce objects spanning scale and application to define spaces that personally connect the user or wearer to their environment while expanding human interactions with the micro and macro spaces in which they move. These will be large-scale installations presented and shared in interactive settings within existing public spaces, with the goal of partnering and exhibiting within education and healthcare facilities as well as our own academic learning spaces.

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