SYMPOIETIC PLEKSIS: THEORETICAL AND PRACTICAL APPROACHES FROM TEXTILES TO ARCHITECTURE

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In the past decades, due to advancements in digital technologies, digital fabrication, and material sciences, there has been a theoretical and design shift. Prior to this, architectural discourse tended to prioritize and segregate form over its materiality, as matter followed the design, creating a clear distinction between design and making. In comparison, craft lies upon the idea of the applied skill and mastery of the material. In craft, matter and its properties are the progenitors of the form alongside the methods of fabrication and forces applied to it. Neri Oxman uses the term material ecology to describe the shift towards new material-based design processes and looks at how craft processes can inform current manufacturing methods. The proposed practice-based research sets out to develop and examine forms of architectural craft alongside fabricating prototypes. It uses textiles as a medium to explore how craft techniques can be re-interpreted to inform our current design and material processes. Textile making is a craft known from prehistoric times. It is a performative action of construction and deconstruction that could be considered the first architecture. Thus, the first known architects can be identified as weavers with the skills to produce structurally complex enclosures. Also, textiles can be seen as a medium to express stories transferred from one generation to another and can indicate aesthetic values, technological advancements, and sociocultural characteristics. The key scope of this paper is to establish the theoretical background that contributes to the conceptual framework of my research. Firstly, it examines the dynamic relations between the maker, materials, and tools. This is followed by an exploration of how such interconnected relationships can be translated to creating design principles and methodologies. Additionally, it includes an overview of textiles in architecture and how they can be used as a fabrication method and as a theoretical metaphor. The process can be seen as 're-coding' the textiles through material choices, pattern creation, computation, and fabrication methods. The paper aims to provide an overview of the ideas leading to creating a dynamic methodological framework, exploring how textile craft can be applied and re-interpreted in an architectural context by emphasizing material programmability and computation.

Keywords: Craftmanship, sympoietic, textiles, making-with, bio-yarns.

INTRODUCTION

There is a long history in architecture between design and production and the association of matter and form. The term architecton is derived from Greek αρχιτέκτων (*architéktōn*) αρχι (*archi*: the lead, the first who commands) and τέκτων (*tecton*: master builder) and traditionally the role of the architect was associated with the work of a master builder (Online Etymology Dictionary n.d.). The physical construction and making were very closely related to the design ideas. At least up to the Renaissance, the master architects had a close relationship with making—craft as most of them were also painters and sculptors (Brothers 2008). With the introduction of architectural drawings and advancements in technology, the role and responsibilities have changed throughout the years. From a highly skilled master in charge of conceptualising, managing the project and the construction; to a contractor in charge of designing and being partially involved in the implementation.

The Industrial Revolution was a key point for this transition with the invention of the printing press, mechanised processes, mass production and standardisation (Carpo 2011). This shift has led to a decline in traditional building craft due to the need for standardised design processes. Architects started to design in an isolated manner, excluding the traditional building craft driven by technological advancements and craftwork was identified as ornamental (Djabarouti & O'Flaherty 2020).

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The next key shift is the "digital turn", a term coined by Mario Carpo to signify the use and effect of computers and digital technology on architectural design (Carpo 2011). The use of such digital tools is leading to design outcomes that are highly formalistic and are further disconnected from the material choices. There is an imposition of material to form (Picon 2011). Yet, in the past decades with the developments in computation, material science, technology and fabrication there is an attempt to reinterpret craft techniques and create innovative methodologies (Oxman 2014). The paper aims to provide a brief overview of the theoretical background related to craft processes, particularly looking at textiles and how they can be used to expand and explore new architectural methodologies.

1. THEORETICAL BACKGROUND

Craftmanship may be reinterpreted as a set of instructions combining knowledge and application, matter and tools. An operational framework for processing and re-organising material constructs. Thus, a craft of any kind may potentially serve as a guiding instruction—set, a formalism witch merges knowledge of application with instrumentality of material organization (Oxman 2014 2).

1.1. DEFINING CRAFT INTERDEPENDENCIES

The term craft comes from Old English cræft (West Saxon, Northumbria) "power, physical strength" and from Proto-Germanic *krab-/kraf-* "strength-skill" (Doyle 2016) (Online Etymology Dictionary n.d.). In his book The Craftsman, Richard Sennett gives examples of craft practices from cooking, potting, weaving, music, and medicine (Sennet 2008). He emphasizes the importance of creating tactile experiences through engagement to form tacit knowledge and relational understanding. Such an approach highlights a constant synergy between thinking, tools, making, development of skill and production. The dialogue between thinking and making leads to habitual rhythms and establishes a close relationship between problem-solving, problem-finding, and the creations of the craftsman's ethical stand (Sennet 2008).

For Pallasma, craftmanship denotes a close collaboration with the material capabilities to inform the process instead of imposing a pre-convinced idea. He mentions that the craftsman needs to listen to the material and establish associations of concept and execution, thinking and making, learning and performance, action, and matter (Pallasmaa 2009). Furthermore, in The Nature and Art of Craftmanship, David Pye defines craft as the result of a process where the outcome depends on the dexterity and care of the maker, and there is no predetermined output (Pye 1978). Core to his definition is the notion of risk during the making process. The risk is managed through the craftsman's skill and knowledge, providing a relationship between certainty and risk (Pye 1978).

If the craft is defined by skill and our active engagement with the material and building processes architects have long been disconnected from the process. This part was instead given to builders and constructors. Digital fabrication, simulations and material science have given the opportunity to reconnect with these processes of making and are key in re-establishing and enhancing craftsmanship methodologies to be applied in architecture, toward a digital craft.

1.2. DEFINING DIGITAL CRAFT

Malcolm McCullough is one of the critical figures discussing the idea of digital craft in 1996. He explores the idea of computer as the medium between hand and maker, claiming that to substantiate the work there is always a need for a medium. The medium facilitates the actions of hands, tools, materials to create a habitual practice. Thus, it can have multiple meanings, it can be raw material, immaterial, an agency, a person, a tool, and a complex process. It can become challenging to indicate when the tool ends, and the medium begins (McCullough 1996). Going back to the notion of risk posed by Pye and its relationship to craftsmanship, there is a need to consider how that affects the definition of digital craft. Within traditional craft, there is no option of going back whereas within a digital environment the notion of risk-taking can be minimal. McCullough, through his work, establishes the basic ideas to define the intellectual understanding of craft through a continually working medium. One of his key points is the notion and importance of density "increased notational density supports quasi–continuous operations formerly only available from physical materials" (McCullough 1996). Based on an increase in computational power thus high precision numerical representations, the data structures allow for continuity and an increased engagement with structural manipulations. Through this process skill and intellect begins to reunite (McCullough 1996). Computational principles are often associated with domestic crafts such as weaving, ceramics and embroidery. Based on this, S. Doyle and L. Forehand urge for cultivating and expanding new cultures of digital craft through CNC and fabrication methods by recalling the historical links to crafts and feminine labor (Doyle & Forehand 2017).

1.3. AUTOPOIETIC AND SYMPOIETIC SYSTEMS

In formulating a new framework based on craft processes, it is key to understand and create the new interdependencies between maker, tools, material technology, and makers ethos. In doing so, autopoietic and sympoietic systems are explored, seeking to comprehend their organizational differences and the effects each could have on a design process.

The principles of autopoietic systems are that they are organizationally closed and can produce their own boundaries, resulting in autonomous units in terms of self-governing (Maturana & Varela 1980). They are structurally linked to their environment; they can adapt according to their local condition and maintain their internal organization. There can be a constant interaction—transmittal—continuous feedback at multiple levels (Boyer 2015). Applications of this theoretical framework can be seen in multiple domains. For instance, Paul Loh argues that craft can be considered autopoietic as it is both self–referential and self-making simultaneously as continuously designing (Loh et al. 2016). This is based on the continuous relationship between material, tool, skill, and technique. Biocomputational scientists are creating agent-based and evolutionary models. In architecture, autopoietic systems are often preferred due to their predictability, automation, and ability to simulate dynamic controlled systems.

Yet there are downsides to this model. Donna Harraway claims that such models could be at risk and can stop us from the capacity to imagine other possibilities, other worlds. She characterizes the use of such systems as the "unthinkable" theory of relations that feeds a utilitarian individualistic model (Haraway 2016). Instead, she proposes a sympoietic model, an idea of tentacular thinking based on co-production, making with (Haraway 2016). Sympoiesis comes from the Greek σύν (syn, together) and ποίησις (poíēsis, creation) for collectively producing. Key characteristics of the systems are the lack of self-defined spatial and temporal boundaries. They are characterized by complex interactions among components that enable them to be organizationally ajar and allow for integrating new information and dynamic organization of evolving, interdependent complexity (Dempster 1998). Sympoietic systems can be complex, dynamic, situated, and historical. A key example, where she describes sympoietic relations, is through the Navajo Weaving–Churro Sheep alliances. She looks at the weavers around Black Mesa, which is closely related to the exitance of Churro—rough sheep brought to America in the sixteenth century.

Over time, Navaho herders have co-developed it as a distinct sheep that relates to the people—to the place and making (Haraway 2016). The sheep ties people to making through patterns of care response-ability. It is an excellent example of the interconnectedness of making—thinking—weaving—locality—situated knowledge and local habitats.

The interrelations described above through Navajo Weaving would act as a starting point to create the new framework. The key principles favouring adopting an overarching sympoietic framework, which can lead to new possibilities and have an emphasis on situated knowledge and locality. The sympoietic system would be used to explore the dynamic relationships between maker, locality, material, tools, and fabrication. The architect becomes the 'architect weaver' who can re-code textiles and create analogies between fibres, materials, patterns, technology, fabrication, body, and environment. The overarching framework will be a sympoietic approach and use textiles—"pleksis" (from Greek πλέκω–for fabricating using fibres) as a means of explorations to create new architectures of digital craft. Textile and technology are derived from the Latin "texere" meaning to weave, construct, fabricate. Furthermore, the key reasons for choosing textiles as a medium are their close relationship with craft, dexterity, technology, and theoretical signification. Thus, they can be explored both as a theoretical metaphor and a construction method.

2. TEXTILES AS A MEDIUM

Weaving is a useful practice, to be sure, and an economic one; but fundamentally weaving is also cosmological performance, knotting proper relationality and connectedness into the wrap and weft of the fabric. Weaving is neither secular, nor religious; it is sensible. It performs and manifests the meaningful lived connections for sustaining kinship, behavior, relational action for—honhzo—humans and non-human. Situated worlding in ongoing, neither traditional nor modern (Haraway 2016).

2.1. TEXTILES AND STORYTELLING

Textiles have always been a key source of telling—narrating stories from one generation to another. The weaver figure in mythology is ubiquitous in a plethora of ancient civilizations, such as India, Native Americans, Central Asia, and Ancient Greece. In Greek mythology, Penelope, Philomena, Arachne, Calypso, Goddess Athena were all weavers who, through their textiles, create storylines. Penelope weaved and repeatedly unraveled whilst waiting for the return of Odysseus Odysseus, an action that binds her with time and denotes her oath to society. On the contrary, Arachne's textile seeks to express her dissatisfaction towards power by challenging the institution of Olympian Gods, which results in her punishment by Goddess Athena to a spider (αράχνη in Greek), so that she can weave meaninglessly for the rest of her life (Kruger 1998). Furthermore, the materiality of the cloths was also a signification of the socio-cultural status and locality of the material. For instance, wealthy women in Athens were working with fine wool and linen, whereas slaves with coarse wool. Weaver, fibers pattern, and loom all become entangled, negotiating their relationship to narrate a story through the material, cloth, and process. An important part of the exploration would be to identify how such relations can be re-interpreted and used in today's context. To further unravel these relationships, I would also look to explore: entanglements (Haraway 2016) lines—weaving—storytelling, (Ingold 2017), relational architectural ecologies (Rawes 2013), relationality (Barad 2007) reciprocal, relationships (Stiegler, 1998) and vibrant matter (Bennett 2010).

2.2. HISTORIC OVERVIEW OF TEXTILES IN ARCHITECTURE

Architecture and textiles trace date to the first human dwellings, where branches and plant fibers were woven together to provide shelter. The earliest finding of tent structures made from branches, leaves, barks, animal fur and kin is estimated to be from 30,000 years old camps of Paleolithic hunters in the tundra. (Krüger & Hill 2009). The branches were later replaced by animal cloth and spun woven fibers to create textiles, baskets and tents. Greek, Asian, Egyptian, and South American civilizations used textiles as decorative, functional (baskets, mats, carpets, blankets) and construction materials. According to Semper, threading, twisting, and knotting were among the most ancient human arts derived from everything else, including buildings and textiles. He proposes that the origins of architecture are found in four separate elements, which originate in the arts (clay, wood, textiles, stone), each element being inextricable of material, technique and form. According to his "theory of Dressing", fences for animal pens, woven branches were the early man-made partition wall, thus the first space definers (Semper & Mallgrave 2007). Following Semper's logic, Adolf Loos in his essay "the Principle of Dressing" encouraged architects to first engage with textiles to grasp meaning and aesthetics and then apply—employ that to architecture (Loos 1989).

In the 20th century, Anni Alberts emphasized the importance of material and structure in weaving and explored their similarities to architecture. For her, it is key to work with the material's properties and not by imposing a design (Albers, 1965). Architecture and textile have been instruments to express theory, aesthetics, and fabrications of an era. "Architextiles" is a hybrid term looking into uniting the worlds of architecture and textiles. These relationships are also investigated in the literature through books, journals and exhibitions: *Architextiles AD* (Garcia, 2006), *Extreme Textiles designing for high performance* (McQuaid, Becker, & Beesley 2005), *Textile Architecture* (Krüger & Hill 2009), *Skin + Bones: Parallel Practices in Fashion and Architecture* (Hodge 2007), and *Textile Tectonics* (Spuybroek 2011). The theoretical shift during the late 90's and the advancement of technology made fabrication and material sciences working with textiles a promising research field. To this end, textiles as an interface can be an excellent platform to explore and challenge the relationships of making, craft, tools, technology, and digital fabrication.

2.3. RECENT OVERVIEW OF TEXTILES IN ARCHITECTURE

In the field of textile design during the 1980s, there have been great advancements in high-performance fibers, primarily in geotextiles, aerospace and military industry performance (McQuaid, Becker, & Beesley 2005). Textiles can offer a high level of customization by varying the fibers, composite fiber combination and use of various weave techniques performance (McQuaid, Becker, & Beesley 2005) . Knitting, weaving, braiding, and embroidery have a long history of craft and techniques as they have been evolving through centuries. The inherited knowledge accompanied by high-performance fibers and the ability to locally control the structure could lead to promising levels of built performance (Oxman et al. 2010). Thus, textiles can become an excellent platform to explore how material programmability can inform the design of a continuous heterogeneous form with varying properties. Knitting can allow for various performances within a continuous single-form system (Scott n.d.). Such systems with hierarchical relations are useful for multi-performative hybrid structures (Menges & Reichert 2012).

Thomsen has pushed the boundaries and explored textile processes and the idea of highly specified materials in response to design criteria. The knitting pattern becomes a material code that details the structural logic of the form (Thomse & Bech 2012). Through the projects Listener and Strange Metabolism the logic of knitting is exploited and used to create material designs in response to the structural and programmatic requirements of the environment. Slow Furl and Lace Wall investigate how the textile can become an integral part of the structural support (Thomsen 2008).

Furthermore, Jane Scott explores heterogeneity and hierarchy in knitted forms through moisture actuation on fabrics using natural materials. This is achieved by controlling the knitting pattern, fibers with different properties and wood veneer placed within the fabric. The knitted pieces exploit the material properties and actuate once exposed to moisture. Additionally, there are key examples of textiles as part of hybrid systems. Knitflatable combines both pneumatic and knitting systems (Baranovskaya 2016). "Semi-Toroidal Textile Hybrid Installation" introduces elastically bent beams that allow the pre-programmed textile to pre-stress internally and resolve its equilibrium. Similar work achieved a uniform piece of textile that integrates both tensile and bending active elements (Ahlquist & Menges 2013). Finally, Philip Beesley designs and fabricates highly complex self-organized scaffolds based on knitting and folding techniques using various materials (soft, hard, mechanical, living, non-living). All components are interweaved together to produce a fabric that responds to the environment (Beesley 2010).

Despite the wide scope of the projects, it is evident that the process of knitting as a fabrication method and material science has not been explored to its full extent; as a tool for creating highly complex designed structures. Most projects examine a part of the material programmability without a cross-scalar and interdisciplinary approach. It is essential to look at engineered textiles across disciplines such as space design, medicine, bio-design, filtration systems, sailing and landscape engineering and feed that into the design process. Furthermore, most projects concentrate on one key advancement, which could be seen as a more autonomous—autopoietic approach. Part of the scope of the research would be to explore how textiles can enable us to establish and create sympoietic processes.

3. PROPOSED STUDY

Textiles would be used to explore a sympoietic approach of making through material choices, pattern design, fabrication methods, and digital simulations. Textiles and textile processes have proven to be an excellent platform to explore complex ideas; due to their hierarchical structure, they can be programmed to create complex shapes of variable properties and performance (Menges & Reichert 2012). The research will run in parallel strands. One that explores the creation of interdependencies and situated practice—creating alliances through the making of the textiles under a sympoietic framework (Figure 1). This means examining making, programming the material by considering the relationality of material—maker—local material signification—material agency. The second strand would examine in parallel scientific and computational methods for the fabrication and material programmability of the textiles. The following methods would be employed to achieve the second part of the exploration.

4. METHODS

The methods would be explored in parallel, each informing the other to examine their interrelations and inter-actions through a sympoietic making methodology. The three key elements can be seen as relational to the main elements of producing craft - material, technique, tools and make input (Figure 2).

- *material—material programmability*: looking in-depth into understanding the material properties and potential of material programmability; and examining what it could mean for the maker to design and fine-tune the material itself based on the concept of the project.

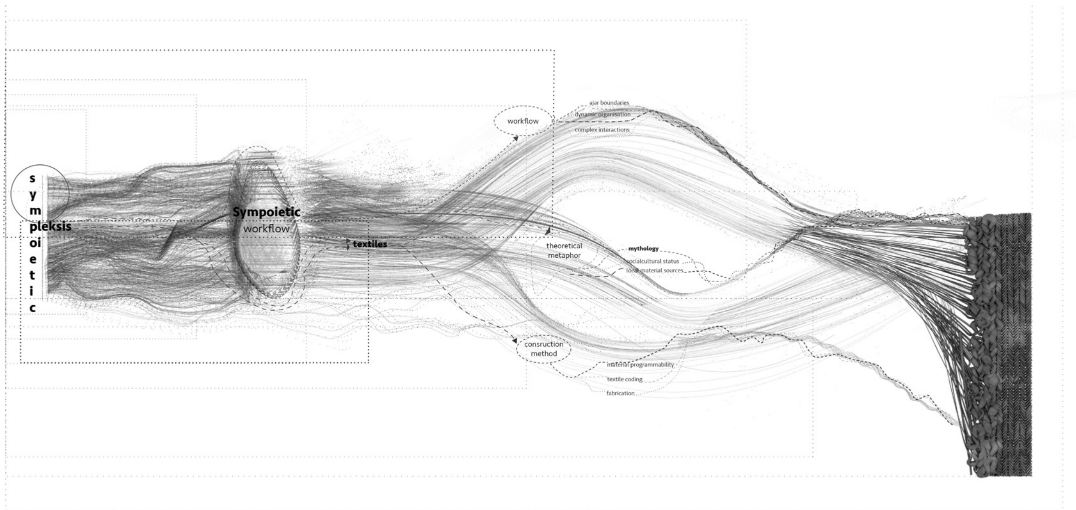

Figure 1: Sympoietic Pleksis, thesis outline diagram: theories-concepts-fabrication 'woven' together. Source: Author 2021.

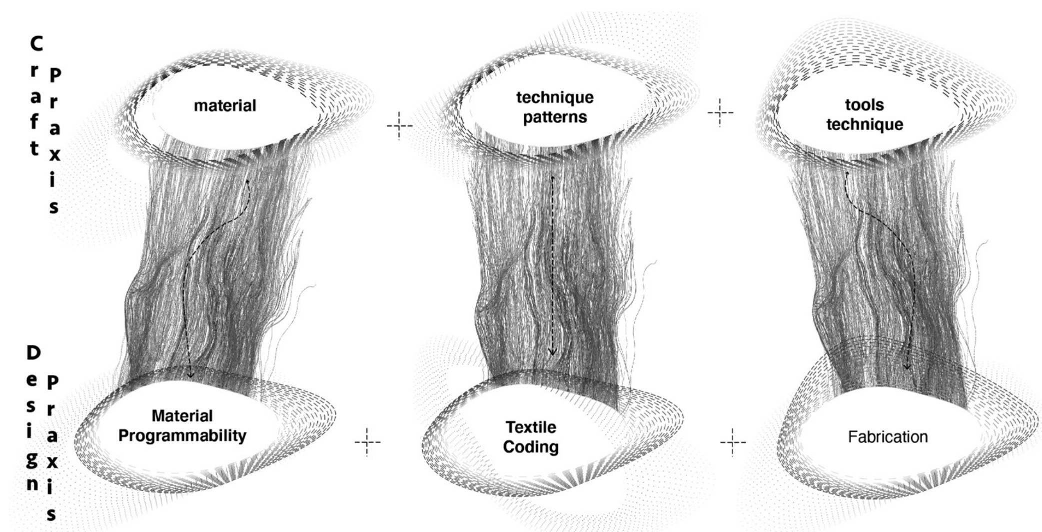

Figure 2: From craft praxis towards expanding digital craft practice. Source: Author 2021.

- *technique—textile coding*: examining various textile-making techniques and the impact the technique and pattern would have on the final form. This could be explored through physical making and through simulations. Textile coding relates to programming the textiles' performance by understanding the fibers' agency and various textile techniques and their effect on the form. The explorations of patterns can be examined to express and explore the relationalities of the maker with the fabric, its materiality, and its locality, as per Donna Haraway's Navaho Weaving example.
- *tools—fabrication*: testing various fabrication methods and tools to scale up the process.

As part of this exploration, it would be key to explore and record how one process affects the other and at which point. Spider diagrams would document the relationships between material, technique, and tools to map the process. Paul

Loh has tried a similar method using diagrams to examine the workmanship of risk and certainty during mass and craft production by conducting semi-structured interviews of artists (Loh et al. 2016).

4.1. MATERIAL PROGRAMMABILITY

In the last decades, there has been a vast number of advancements and literature around material systems, material agency, material programming, biomaterials across disciplines of material science, chemical engineering, architecture, textile and product design (McQuaid, Becker, & Beesley 2005; Oxman et al. 2010; Ahlquist & Menges 2013). Material ecology, a term coined by Neri Oxman defined as:

An emerging field in design denoting informed relations between products, buildings, systems and their environment. Defined as the study and design of products and processes integrating environmentally aware computational form generation and digital fabrication, the filed operates at the intersection of biology, material science and engineering and computer science with emphasis on environmentally informed digital design and fabrication (Oxman 2014).

She also uses the term “variable property” design to describe a design approach and methodology in which material assemblies of varying properties correspond to multiple and continuously varied functional constraints. In this approach, the properties of the materials are used strategically to generate the form (Oxman et al. 2010). This principle is explored in the project form follows flow looking at the potential in architecture to tune and program the material to create a complex, continuous structure with variable stiffness. For example, in the project biopolymers extruded from airtight barrels show elastic and plastic behavior depending on the consistency of the material (Oxman 2015). Furthermore, based on similar principles in the field of textiles and fashion, bio-yarns are created with the use of similar substances, testing a variety of consistencies to create sustainable yarns with various properties.

In the textile and fashion industry, several projects started to push for sustainable solutions for creating composite materials or yarns through biological processes. For example, Bastian Beyer’s in his Ph.D. thesis, explores the potential of solidifying knitted structures through biological solidification with the use of a bacteria which produces a calcite layer on the structure and binds it together (Beyer & Palz 2019). Also, a recent project at Central Saint Martins by Jen Keane in which weaving and production of bacterial cellulose have been combined to create a homogenous form (Jen Keane—MA Material Futures n.d.).

The above projects signify the beginning of a new era in which materials with tuned properties are part of the design form-finding method to create a multi-performance form responding to predefined criteria. The research would examine how we could explore the interconnected relationships with the maker, the making process, and its relationship with the environment through material programmability. The critical part would be to identify the composition of the thread, as natural but also as an artificial fiber, which can be programmed to respond to predefined stimuli. The fiber can be seen as a filament used to create spaces through knitting, weaving, binding, patterning, connecting, intermingling, and can happen with various materials of different states. It would be crucial also to examine the relationship the materials have with their signification and their relationship with the ecological and socio-cultural environment.

The main part of this process would be to identify a material pallet of fibers. This could comprise existing fibers and composite fibers and investigate development making tunable fiber bio-filament (Figure 3). There are two main aspects to explore. Firstly, the performance of the fibers and in particular the parameters that would be explored would be a) the type of yarns structure used:

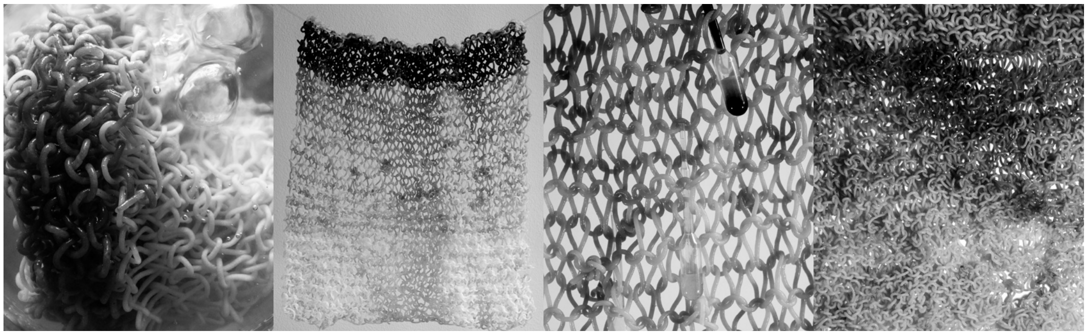

Figure 3: Making and experimenting with bio-yarns infused with living marine algae to explore the relationship between our environment, the textile, and the microorganisms. Source: Author 2021.

monofilament, multifilament, ply yarn, covered yarn, spun yarn, b) tensile strength and elongation of textiles, c) bending stiffness, d) drapability, e) response to stimuli (i.e., moisture, measure the shrinkage rate). Secondly, various mixing protocols for the creation of tunable biopolymer filaments. The making of the biopolymers is of great interest because the materials can be tuned to relate to required local and environmental conditions. The materials used would be water-based-composites of biological ingredients which tend to be environmentally responsive (Ling 2019). The materials can be "bio-based", such as casein, chitosan, cellulose, pectin, sodium alginate and "bio-active", such as algae. There are multiple challenges in working with biopolymers, such as the strength of the filament, diameter of the filament. These would be addressed by testing multiple recipe consistencies and curing methods with the input from material scientists. The behavior of the fibers would be measured and recorded to feed the simulations and form finding process.

4.2. TEXTILE CODING

There is a clear connection between the computation and the textile pattern, as each knot could be translated directly into the digital environment (Popescu et al. 2018; Tamke et al. 2021; Narayanan et al. 2018; Tamke et al. 2021). This makes it a powerful tool to work with and has great control over the final output. Also, the granularity of the data and its instant relationship with the physical world can relate to McCullough point on digital craft and connection to data.

Computational methods would be used to design the patterns and understand the fabric's behavior and response to various stimuli. The data from the material tests would be used to inform the behaviors of the models. The simulations and computations would be used both to inform the design fabrication, predict the textile behavior and act as a speculation tool. The speculation part would be used as a medium to enhance the imagination and envisage possibilities (Figure 4). McCullough's regards the medium as something which affects human senses in a matter that commands our attention and stir our imagination (McCullough 1996). According to Doy, craft encourages imagination and is a powerful agent "the ability to imagine a better word equipped with the capacity to act, is to craft and object with intentionality and purpose" (Doyle & Forehand 2017).

The key computational method that would be used is Grasshopper, for creating the pattern and conducting the structural analysis through Karamba and simulating the behavior of the textile (Figure 5). Furthermore, Houdini would be used to conduct the simulations of the textile behavior, such as the impact of the pattern on the form, how various material turnability can affect the form (for instance, part of the structure might shrink or change color) and as a medium to extend our imagination. Finally, the explorations would lead to a re-coded textiles-pattern aesthetic.

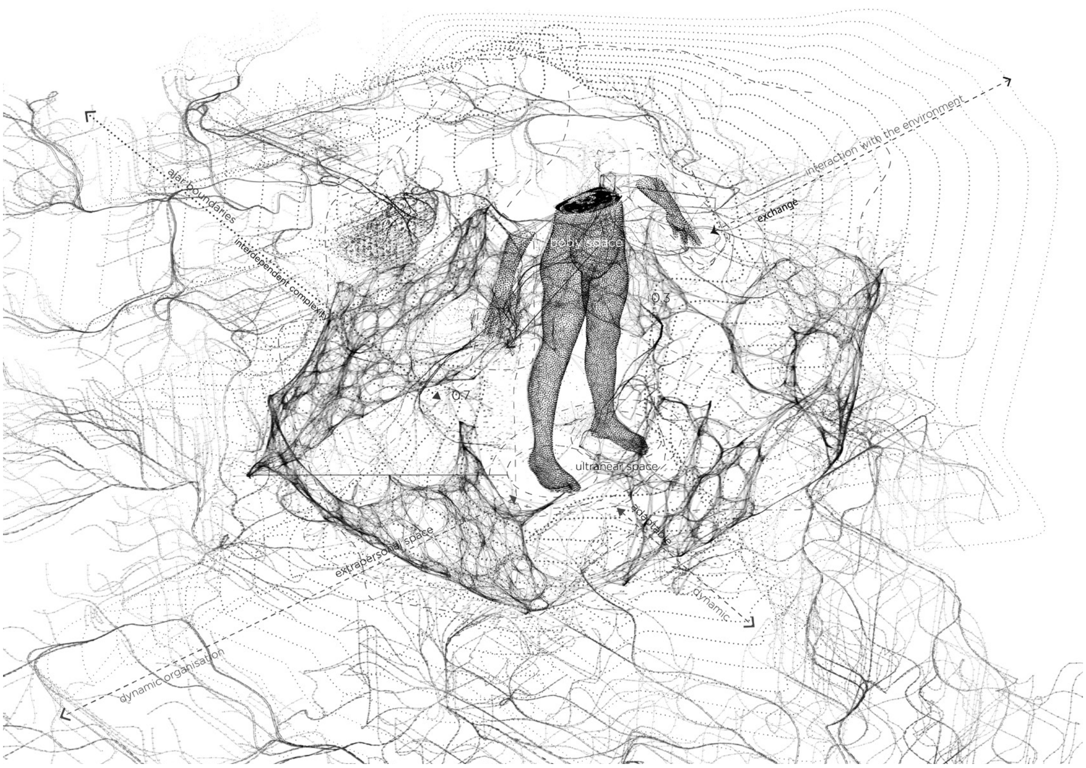

Figure 4: Exploring through Houdini, the behaviour of the fabric and producing speculative drawings that explore the inter-relationships of weaving- material-body- environment. Source: Author 2021.

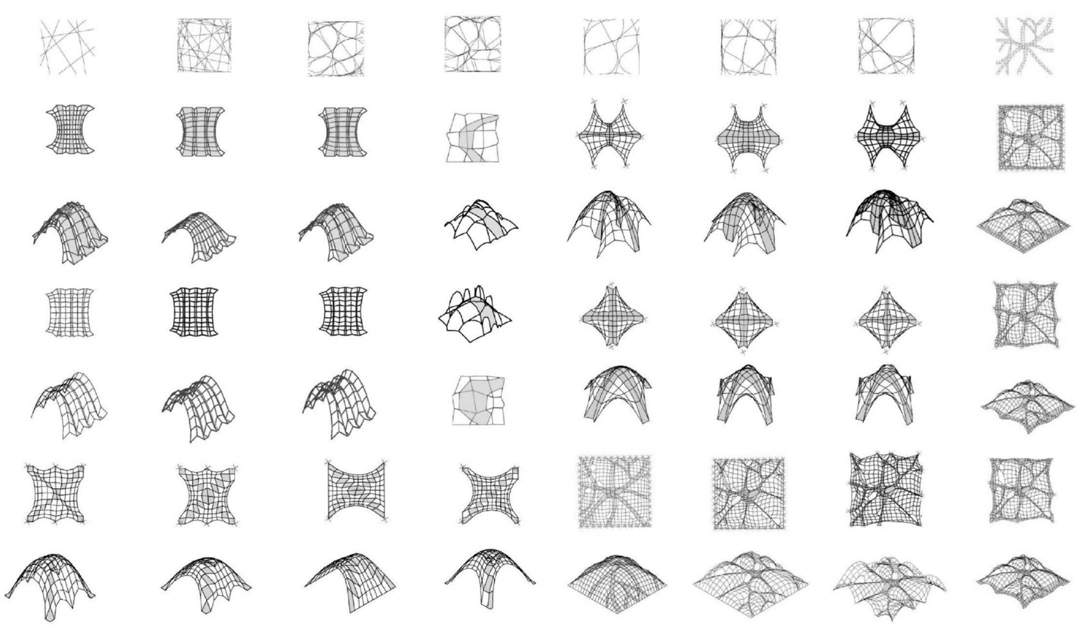

Figure 5: Exploring fabric behaviour & activation in grasshopper. The impact of the pattern and of material properties (in particular shrinkage) on the final form. Source: Author 2021.

4.3. FABRICATION

This phase is closely related to the material testing, the textile coding. It will occur in parallel with the other two and will be an iterative process. An important part is testing and setting up methods for scaling up the processes. Architectural textiles would be constructed by exploring various fabrication methods, materials, patterns, their impact on the final form and their interdependencies with the maker and the environment. A fundamental part of this step would be to use cutting-edge technology such as robotics and high-end knitting machines to test and explore the scaling up of the process. Robotics can also extrude the bio-yarn filament to create continuous yarns of varied thicknesses. There would be two main challenges for using existing knitting machines on the prototypes with the bio-yarns. The first one would be the tensile strength of the yarns, and the second would be the yarns' thickness. Knitting machines have a set thickness they can withstand. Thus, depending on the prototype needs, there would be an opportunity to create a simple system or tool to support the requirements to reach the desired output.

There could be multiple challenges for scaling up the process, such as the fibers' size, how the technique used gets translated to a larger scale, and the limitations that might come with the use of tools. It will be key to understanding how the selected materials can work together, and mixing techniques could be needed. A few examples of the techniques that would be considered are looking at: a) spacer fabric structures and how they could be used in an architectural context b) looking at ways of locally solidifying parts of the textile to act as structural support, this could be through the programmability of the fibers themselves c) using the shrinkage of the biopolymers to test if it could create tension within the structured) testing mixed techniques such as weaving within the structure, bending active elements, or using pneumatics and foams to stabilize parts of the structure. All these choices would be made possible when their initial material tests and simulations start.

These steps would come together to produce a series of architectural textiles and speculative drawings that would narrate and explore novel ways of thinking and fabricating architecture.

CONCLUSION

The main aim of this paper was to present a brief overview of the background knowledge of craft by looking at the interrelationships between making, maker, material, and tool. Furthermore, looking at understanding the autopoietic and sympoietic systems as a way of expressing and exploring such relations. Through developing such an understanding, we would be able to create and expand on new cultures of architecture and digital craft. Textiles would be used as a medium of exploration to examine these inter-actions. An initial framework is described based on how the study is intended to be conducted. The project requires input from multiple disciplines such as material science, architecture, computations, engineering and could introduce original perspectives to each field and shed light on those intricate relationships. Finally, it will seek to provide new perspectives and a critical re-evaluation of the textile-based material practice in architecture through a lens of an "architect–weaver–teller–a co-produce".

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